SPACE SOLAR POWER MULTI-BODY DYNAMICS AND CONTROLS, CONCEPTS FOR THE INTEGRATED SYMMETRICAL CONCENTRATOR CONFIGURATION

FINAL REPORT

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Space Solar Power Multi-Body Dynamics and Controls, Concepts for the Integrated Symmetrical Concentrator Configuration Final Report Contract NAS8-00151

1.0 INTRODUCTION

Orbiting space solar power systems are currently being investigated for possible flight in the time frame of 2015-2020 and later. Such space solar power (SSP) satellites must be extremely large to make practical the process of collection, microwave conversion, and reconversion to electrical power at an earth station or at a remote location in space. Many different configurations have been proposed by various study groups over several years of study. We will not review these concepts but instead, will concentrate on the one which has been defined to be our focus for this study, the Integrated Symmetrical Concentrator (ISC). The Integrated Symmetrical Concentrator (ISC) is composed of two very large, segmented reflectors, shaped like clamshells. Each reflector is a flat mirror and each clamshell contains 36 such reflectors. These are individually mounted and aimed to concentrate the reflected sunlight onto two centrally located photovoltaic arrays. The sunlight is converted to electrical energy and transmitted by cabling to a large transmitter, which in turn converts the electrical energy to RF energy and beams it to a dedicated rectenna site on Earth. The transmitter is suspended between the two PV arrays, providing an adequate view of space from the back of the transmitter to manage the thermal loads. The metering structure, which maintains the positions of the clamshell

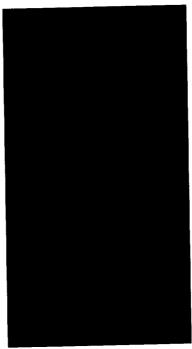


Figure 1.0.1 Artist concept of Integrated Symmetrical Concentrator, courtesy of NASA.

reflectors, is a long, flexible beam aligned with the orbit normal. Bearings and drives at each end rotate the clamshells to track the sun throughout the orbit, and tip them for beta tracking. The ISC is to operate in geosynchronous equatorial orbit. An artist sketch of the ISC configuration is shown in figure 1.0.1. The expected power output from the radiating antenna at GEO will be approximately 2 gigawatts. With conversion and radiation losses this is expected to result in 1.2 gigawatts at the output of the earth station. From this discussion it is evident that the operating attitude of the ISC satellite is to be perpendicular-to-the-orbit-plane, the POP attitude. The sunlight collector sections must point toward the sun and since the

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sun motion relative to the earth completes one revolution in a year, the collectors must rotate approximately one degree per day. In addition, they also are tracking the sun's northerly and southerly excursions of +/-23.5° per year relative to the equatorial plane. Meanwhile, the radiator section must track the earth station location, rotating once around per day. For purposes of these studies, the earth station is assumed to be a point on the earth's equator. Any earth station latitudes other than zero are to be reached by use of electronic beam steering. All power conversion for the ISC configuration is envisioned to occur at the center section in order to minimize the requirement for cabling and power transfer from one section to another. From this discussion, it is clear that the concentrators must be hinged relative to the center section to accommodate these different rotational motions. Two concentrators are provided for symmetry and must be sufficiently separated from the center section for proper focus. The boom is required to position the clamshells, maintaining their focus and providing support. The clamshells are umbrella shaped structures which reflect the sunlight onto photovoltaic arrays near the center of the ISC. The clamshell normal unit vectors bisect the angles between the sun line of sight vector and the orbit normal vectors. This is required to keep the sunlight directed onto the PV arrays. The planes of the PV arrays are not perpendicular to the boom but are rotated 20 degrees so that they have a sufficient view of deep space for proper thermal radiative cooling. The entire central section called the central body in the following, rotates once per orbit (one orbit = one day, 24 hours) maintaining the power beam pointed at the earth station and carrying the PV arrays along with it. The boom structure rotates with the central body in all control concepts except concept 1. In concept 1 there is a single relative degree of rotational freedom about the central body's Z axis. All control concepts 1, 2A, 2B, and 3 will be described in more detail in later sections of this report.

1.1 STATEMENT OF WORK

The National Aeronautics and Space Administration notified bd Systems in April of 2000 that our NRA8-23 proposal number PL90059A entitled "Multi Body Dynamics & Controls", submitted May 12, 1999 was selected for funding with a reduced scope. Specifically, tasks 2 and 4 from that proposal were selected. Task 2 calls for the Analysis of a sample problem to be provided by NASA and Task 4 for documentation. For purposes of this study, the sample problem of interest to NASA is the dynamics and control of the Integrated Symmetrical Concentrator configuration described in the following paragraph:

An understanding of the on-orbit dynamics of this configuration is necessary for concept feasibility assessment, the preliminary design of an attitude control system and an estimate of stationkeeping requirements. The sample problem dynamics and controls studies have been worked according to the subtasks below:

1.1.1 Subtask 1 – Dynamics Model Development

Develop a dynamics model of the Integrated Symmetrical Concentrator in geosynchronous orbit. A minimum model would consist of two rigid bodies representing the clamshells that track the sun, attached by flexible beams to a central rigid body that tracks a fixed point on Earth. Quantify the pertinent disturbance torques and forces (gravity gradient, solar radiation pressure, gyroscopic, etc).

1.1.2 Subtask 2 - Attitude Control Concept

Propose an attitude control system concept that will maintain clamshell solar tracking and transmitter array tracking of the rectenna-site on Earth. Perform trades on centralized vs. distributed or hybrid control architectures. For the 1.2 GW configuration to be built after 2020, develop estimates of torque/momentum requirements, identify suitable actuator locations and develop a top-level mass estimate for an attitude control system, with propellant mass estimates. Identify risks and feasibility issues ("tall poles") with the proposed attitude control concept.

1.1.3 Subtask 3 – Documentation/Deliverables

The dynamics and control model (developed in TREETOPS or another suitable modeling computer code) for the Integrated Symmetrical Concentrator with flexible booms including any additional modifications or enhancements to TREETOPS will be delivered to NASA in the forma of a CDROM. This will contain a PC version of the operational TREETOPS software accompanied by source code and data files.

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A final report that documents the dynamics and control model development for the Integrated Symmetrical Concentrator, and documents the trades, mass estimates, recommendations and risks for the proposed attitude control system. Microsoft Word and Power Point will be employed to describe in detail the dynamics and control model development and simulations, etc.

1.2 STUDY GROUNDRULES AND GUIDELINES

TREETOPS is a general purpose multi-body flexible spacecraft dynamics simulation computer program which was used as the modeling tool for performance of this study. Previous to the study, an enhancement was made to the orbital environment model to a general, non-spherical earth model. During the study enhancements were also made to the sensor models to provide features required by our candidate SSP such as an earth target pointing error sensor, a line of sight 3 axis attitude error sensor, and a sun/star presence flag. NASA/MSFC provided ISC geometry and mass properties to us early in the study. In addition, it was agreed that we would freeze this configuration for study purposes. Dr. Stephen Canfield's work for MSFC as a Summer Faculty Fellow would be the basis for our flexible boom model. Bd Systems built a NASTRAN flexible body model of the boom using inputs obtained from reference 1. This flexible body model was reduced to 24 flexible modes and was incorporated into the ISC model.

The controllers defined for the ISC configuration were all conventional continuous, linear controllers. Conservatism in design and implementation was a guiding principle in this study. This allowed all controllers to built using standard TREETOPS features without requiring the use of any special, user-defined functions or subroutines. TREETOPS standard sensor and actuator models were employed to define the controller implementations. This included, in some cases new TREETOPS coding to add or modify a sensor model to fulfill a specific requirement for certain functionality not provided in the previous version.

1.3 GOALS AND LIMITATIONS

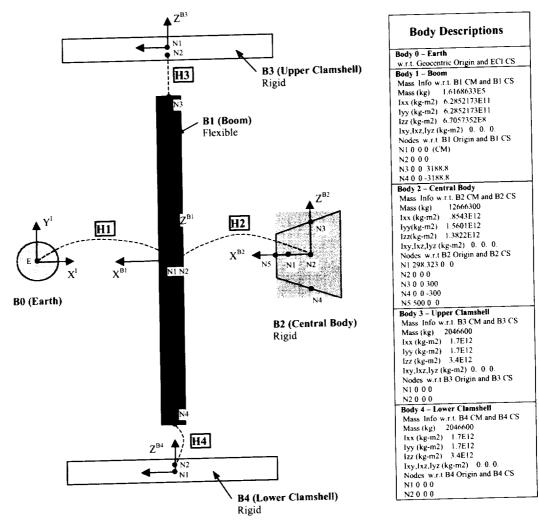
The goal of this study is to develop a range of controllers for the ISC SSP configuration, which demonstrate control capabilities and allow the requirement for consumables and/or momentum storage capacity to be quantified. A total of 4 control concepts were defined and implemented in the TREETOPS ISC simulation. These covered the range from entirely conventional, centralized control to a multi-body distributed control and demonstrated a range of performance levels showing the features, advantages and disadvantages of each. Detailed description and simulation results will be presented in later sections for each. It must be stated that out of necessity, the ISC configuration, which we have used and for which our results are valid, represents a snapshot in the evolution of the ISC configuration. In the larger NRA activities ISC development has continued. It was necessary for the concept we studied to be frozen in order for the study to be performed and the configuration taken represented a consensus compromise.

1.4 ANALYTICAL TOOLS

As mentioned previously, the primary analysis tool employed for this study was the multi-body modeling code TREETOPS, version 10P2 with capability enhancements developed by bd Systems Control Dynamics Division under several NASA contracts including the present one. Secondary analysis tools included the structural modeling, finite element analysis system known as NASTRAN, the CSA NASTRAN variation. We also employed the Math Works Matlab® version 5.3 for processing the data and generating the plots.

2.0 SYSTEM DESCRIPTION

The ISC configuration is illustrated in figure 2.0.1 below as it is laid out for TREETOPS modeling. The model consists of four bodies: 1. The metering structure boom or simply the boom; 2. The solar collector, power converter and radiator, alias the central body; 3. The upper solar concentrator or clamshell; and 4. The lower clamshell. These bodies are described for modeling purposes by their geometry and mass properties shown in the table to the right of the figure. The basic operation of this configuration is to point the central body radiating antenna at the earth station while keeping the clamshells properly pointed to



				714
Description	U1	H2	Н3	H4
Description	111			0
Concept 1A	$3-L1(X^{1}),L2(Y^{1}),L3(Z^{1})$	1- L1(Z ^{B1})	0	2 1 1 (VBI) 1 2 (VBI)
	2 11(V) 12(V) 13(7)	0	2- L1(X ^{B1}),L2(Y ^{B1})	2- L1(X31),L2(Y31)
Concept 2A	3- L1(X'),L2(Y'),L3(Z')		- III (BI)	$2-L1(Z^{B1}),L2(X^{B1})$
Concept 2B	3- L1(X'),L2(Y'),L3(Z')	U	B	$\frac{1}{2}$ 1.1(7 ^B) 1.2(V ^B) 1.3(V ^B)
	$\frac{3}{2} + \frac{1}{2} (X^{1}) + \frac{2}{2} (X^{1}) + \frac{3}{2} (Z^{1})$	1 0	$3-L1(Z^{B1}),L2(X^{B1}),L3(Y^{B1})$	3-LI(Z),L2(A),L3(1)
Concept 3	3-LI(X),L2(Y),L3(Z)		· ·- ·- ·	

Figure 2.0.1 TREETOPS Model of SSP Integrated Symmetrical Concentrator.

beam solar energy onto the PV arrays. Each clamshell contains 36 flat mirrors that are set at proper angles to focus a spot of light on the PV array. Each is positioned uniquely such that focus is degraded significantly if the clamshell is rotated about the boom even though the plane of the clamshell is maintained. An early control concept (now referenced as concept 2a) was eventually ruled unacceptable

because it did just that. It was maintained in the study for comparison purposes to study performance and propellant comsumption.

2.1 CONFIGURATION AND ASSUMPTIONS

The reference coordinate system employed for TREETOPS analysis in shown in figure 2.1.1. This is the inertial coordinates system used for dynamic calculations. In this reference frame, the position of the sun relative to the earth changes over the course of the year. In the spring, at the time of the Vernal Equinox

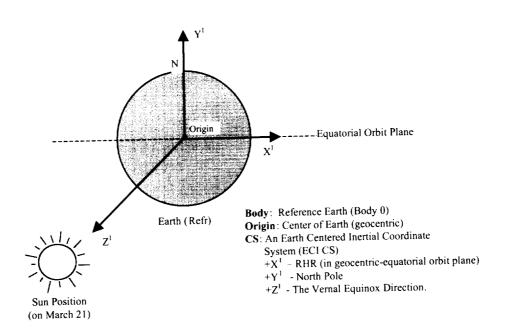


Figure 2.1.1 TREETOPS Inertial Coordinate System.

(VE), around March 21, of the year, is the time of year when the sun appears to pass from the southern to the northern celestial hemisphere through the equatorial plane. Other significant times are June 21, Summer Solstice (SS), sun most northward (23.5° north celestial latitude), September 21, Autumnal Equinox (AE), north to south through the plane and December 21, Winter Solstice (WS), sun most southward (-23.5° celestial latitude). These times provide samples of the different attitudes the ISC must operate in over the course of the year. The first body defined for the ISC is the boom. The boom body axis system is defined with its long axis along Z. The two transverse axes are X and Y respectively and are assumed to be symmetric.

A set of 3 Euler angles defines the TREETOPS hinge 1 rotational degrees of freedom. Figure 2.1.2 shows the orientation of the intermediate axis Z' after rotation through the 1st Euler angle defined about inertial X which rotates the boom Z axis along the inertial Y. The second Euler angle defined is about the intermediate Y' axis. The third Euler angle is about the second intermediate axis Z". The initial position of

the boom, body 1 relative to the TREETOPS inertial frame is specified by the 1-2-3 Euler angle sequence from the TREETOPS inertial frame to the body 1 frame with the angles -90°, 0°, 90° respectively. Figure 2.1.2 shows the initial rotational position of the body 1 frame and the TREETOPS inertial frame. Three translational degrees of freedom are also defined for body 1 and the initial translation position and velocity places the system into a geosynchronous, equatorial orbit. Body 2 is the central body and is positioned by hinge 2 relative to body 1. Only in control concept 1 does hinge 2 have any degrees of freedom defined.

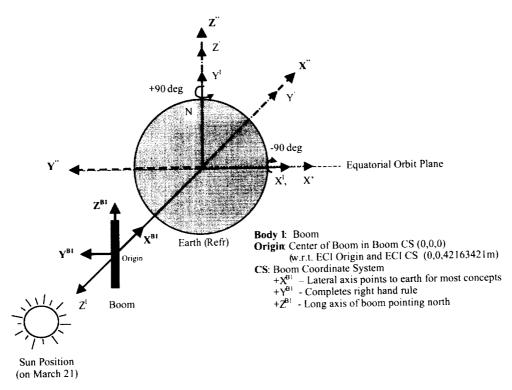


Figure 2.1.2 TREETOPS Body 1 (Boom) coordinate system at Vernal Equnox. Boom CS at Vernal Equinox initial condition = [90°]₃ [0°]₂ [-90°]₁ expressed as Euler angle sequence.

Concepts 2a, 2b and 3 have all degrees of freedom locked at this hinge. For concept 1, a single rotational degree of freedom is defined for Z axis relative motion. Body 1 and body 2 are aligned initially at the Vernal Equinox. Since body 2, i.e. the central body tracks the earth station, it must rotate at orbital rate, once per day. Thus, except for control concept 1, the boom also rotates once per day.

The clamshells are attached to the upper and lower ends of the boom. The upper clamshell is TREETOPS body 3 and attached to the boom at hinge 3. The lower clamshell is TREETOPS body 4, attached to the boom at hinge 4. Hinges 3 and 4 are defined similarly to each other but are different for each control concept. They range from 0 defined degrees of freedom for concept 1 to 3 defined degrees of freedom for concept 3.

The concepts introduced above are several control scenarios simulated to provide attitude and pointing control for the several components of the ISC. They will be defined in greater detail in a later section. Concept 1 is also occasionally referenced as concept 1A as there was originally a concept 1B. Concept 1B was eventually dropped because we judged it to be insufficiently different from concept 1A.

2.2 GEOMETRY AND MASS PROPERTIES

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Figure 2.0.1 summarizes the structure of the TREETOPS model of the ISC as well as its geometry and mass properties. Addition of the component masses yields the total mass of the ISC configuration: 16.921x10⁶ kilograms, nearly 17,000 metric tons. The dimensions expressed in figure 2.0.1 were provided by NASA/MSFC in reference 2 along with the component masses. Each major component mass was idealized as a disk, a rod or an assembly of disks and rods. From these assumptions, the moments of inertia were calculated. The results of these calculations are summarized in the table of the figure. The moment of inertia of a rod about its center of mass is

$$I = \frac{1}{12}ml^2.$$

Similarly, the moment of inertia of a disk about an axis through its center of mass and normal to the surface of the disk is

$$I = \frac{1}{2}ml^2.$$
 [2]

The moments of inertia about the two transverse axes in the plane of the disk are each half the moment of inertia about the normal, equation 2. These facts are sufficient to estimate moments of inertia for bodies 1, 3 and 4. The moments of inertia of body 2 are computed by adding moments of inertia of 3 disk like structures, representing the two PV arrays and the radiating antenna.

The TREETOPS model description input files for all the control concepts and all the seasonal runs are contained in Appendix A.

2.3 FLEXIBILITY MODELING

The boom was deemed the critical member of the structure from the flexibility perspective and was the only body in the TREETOPS model defined as flexible. Dr. Canfield's study, reference 1, was used as a basis from which we developed a NASTRAN finite element model of the boom structure. Structural modes were generated from this NASTRAN model and the frequencies from this model are contained in Appendix D. The boom flexibility model is developed as a free-free model using the Craig-Bampton reduction technique. A total of 30 modes are calculated and the 24 flexibility modes are taken into TREETOPS to describe the boom flexibility.

The TREETOPS model for the ISC including boom flexibility varied among the different control concepts due differences in the hinge degrees of freedom defined for each. TREETOPS generated mass and stiffness matrices were used to compute combined system modes and frequencies for the uncontrolled systems. These results are presented in Appendix C.

2.4 DISTURBANCE MODELING

The principle disturbances affecting the ISC configuration at synchronous orbit altitude are gravitation and solar radiation pressure. Gravitation determines the orbital motion and the gradient of the gravitational force field causes tidal forces and torques that load the structure and perturb the attitude. These forces/torques are built-into TREETOPS. Reference 3 includes a description of the development of the enhanced gravitation and solar pressure models added to TREETOPS along with the verification of these changes. Especially important in this process is the inclusion of these loading effects on body flexibility and flexible body deformations.

2.4.1 THE GRAVITATIONAL FORCE

The Earth gravitational force field is modeled in TREETOPS by the default field model, which includes field expansion terms through J4 (see Reference 4). Gravity gradient (GG) torques and flexible body

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generalized forces are also modeled through this order. Reference 3 contains a detailed development of these expressions. Concerns were expressed regarding the ability of the ISC structures to withstand the GG loading. Simulations did not show this to be a significant problem.

2.4.2 SOLAR RADIATION PRESSURE

The relatively lightweight structures and large surface areas required to capture the solar energy sufficient to radiate approximately 2 gigawatts at the output of the radiator after conversion losses in several stages of conversion makes solar radiation pressure a significant disturbance source along with GG. The clamshells possess the largest surface areas of the ISC structure. Based on the dimensions given in reference 2, 10,400,000 m² was the area of each clamshell. These were modeled as planar areas having a normal along the z axis of the clamshell body, a centroid at the attach point of the solar collection/reflection surface and a reflectivity of 100 percent. The boom was modeled in solar pressure as 4 planar surfaces in successive 90 degree positions around its circumference. Each surface was subdivided into 3 segments, a center segment an upper and an lower segment. The center segment had an area of 638,000 m², the upper and lower each had areas of 319,000 m². These 12 total surfaces areas were attached at the center node of the boom and the upper and lower end nodes of the boom. This model somewhat exaggerated the boom solar pressure area and was deliberately done this way for conservatism and simplicity. The 12 surfaces were used to allow the radiation pressure to act on the separate nodes of the flexible boom and to include to this degree the effects of boom flexibility interacting with the solar radiation pressure. The total area of the boom was still only a small fraction of the area of the clamshells. The central body PV arrays were each modeled by an area of 785,000 m2 and the microwave radiating antenna was modeled by an area of 196,000 m2. The boom radiation pressure model with its 90 degree planar surfaces does produce effects which are occasionally noticeable. These will be pointed out later in our discussion of simulation results.

2.5 CONTROL CONCEPTS

The successful operation of the ISC configuration requires that the clamshells concentrate sunlight on the photovoltaic arrays. The PV arrays must then convert this sunlight into electrical power. This electrical power is then transferred to another converter where it is transformed once more into microwave energy and beamed by a microwave radiator through an antenna to a station on Earth. This process implies several control processes relating to ISC spacecraft attitude and stationkeeping. For operations purposes, it has been decided to maintain the boom in an orientation perpendicular to the orbital plane a so-called POP attitude. From the POP attitude the clamshells must be oriented so that sunlight is collected and reflected onto the PV arrays. This means that each clamshell's normal must be such that that the angle of reflection onto the PV array equals the angle of incidence of sunlight onto the clamshell and all three, the sun, the clamshell normal and the PV array lie in the same plane. Thus, the clamshell normal must be pointed in a direction halfway between the sun and the PV array, which by above assumptions lies in the direction of the orbit normal relative to the clamshell. The clamshell pointing must be sufficiently accurate that the migration of its reflection spot stays on the surface of the PV array. Thirty arc minutes of clamshell motion can cause as much as 1 degree of spot motion and at 3190m separation of clamshell and PV array amounts to approximately 56m of motion. Simultaneously, the energy beam of the central body must point to the Earth station. Electronic beam steering will be used to keep the beam pointed properly, but this can only be used as long as the mechanical antenna pointing is within a small separation of the target. Thus, mechanical pointing of the antenna is required to keep the beam pointed to the earth, which for our application, must be within 30 arc minutes. Based on this discussion, mechanical pointing is required to keep the central body pointed at the Earth while the ISC flies in an equatorial, earth synchronous orbit. Simultaneously, the boom must be maintained aligned with the orbit normal, and the clamshells pointed halfway between the Sun's position and the south or north poles respectively for the upper and lower clamshells. Several concepts have been studied to achieve these control requirements. Also, the ISC's orbital position must be maintained over a particular longitude of earth in a process called stationkeeping. The accuracy required for stationkeeping is understood to be 0.5° of longitude. The focus of this study is spacecraft attitude control. Stationkeeping has not been studied in detail. The propellant estimates given for stationkeeping are made assuming instantaneous balancing of disturbance forces. The following control concepts address attitude control of the ISC configuration only.

2.5.1 **CONCEPT 1**

The most centralized control concept studied in this activity is concept 1. In this concept, the central body is controlled by a pointing and attitude control system. This system points the antenna at the Earth and holds the roll angle around the antenna line of sight such that the boom is maintained along the orbit normal by virtue of its being structurally hinged to the central body. An Earth target sensor is provided by TREETOPS and is employed in this concept and all the other concepts to provide an error signal for central body pointing control. A star sensor and an idealized pole star target provides a roll error source. The TREETOPS hinge between the boom and the central body has a single degree of freedom such that the central body can rotate about the boom Z axis (see figure 2.1.2). A torque motor actuator provides control torques at hinge 2 from an error signal based on output from a sun sensor. The clamshells are each hinged to the boom with a single degree of freedom hinge to allow raising and lowering them to track the north-south annual sun motion. For TREETOPS implementation of concept 1, this degree of freedom is ignored. It is assumed to operate open loop, maintaining clamshell pointing at the proper north-south angle. Boom yaw is maintained to track the annual solar motion. The detail of instantaneous motion of the sun is not currently modeled in TREETOPS and is ignored in all the concepts.

2.5.2 CONCEPTS 2A AND 2B

The next concept studied in this activity is concept 2A. This was actually the first concept studied. The 2 indicates that 2 axes of clamshell rotational motion are controlled. The A indicates it was the first considered of this type. Clamshell pointing is independently controlled by a controller using sensors and actuators located on the clamshell. The sensor is a special 3-axis line of sight (LOS) sensor that employs 2 guide stars to define a pointing direction and a reference for roll about the LOS. As in concept 1, the actuators employed are moment actuators which produce a pure torque with zero force on the body being controlled. Such an actuator could be realized as pair of thrusters of equal thrust producing forces in opposite directions, whose force lines of action are separated by a nonzero distance or moment arm. In this concept, control of the clamshell pointing depends only on clamshell mounted sensors and actuators, whereas in concept 1, clamshell pointing depended on central body control. Thus, this concept is more distributed than concept 1. The distinguishing feature between concept 2A and concept 2B is the definition of the degrees of freedom defining the hinges between the boom and the clamshells. In concept 2A, TREETOPS hinges 3 and 4 are defined by X and Y gimbal angles, i.e. two angles perpendicular to the long axis of the boom. In concept 2B, hinges 3 and 4 are defined by X and Z gimbal angles. The effect of this subtle difference is that the clamshell rotates about the pointing line of sight in concept 2A but not in concept 2B. The clamshell pointing controller operates the same in both. The rotation in concept 2A results from the rotation of the central body and boom which must rotate once per day to track the Earth target. Since the hinge between boom and clamshell in concept 2A only allows relative rotation about boom transverse axes, the clamshells must rotate with the boom. Hence, the flat mirrors on the clamshells are continuously changing their separation and angular relationship with the PV arrays causing an amount of motion of the reflection spot that was deemed unacceptably large. Thus, concept 2A was eliminated from consideration but is retained for discussion and comparison purposes. This led to concepts 2B and concept 3. In concept 2B, the hinge or gimbal structure between boom and clamshell is first a rotation about the boom Z axis, followed by a rotation about the displaced X axis which is fixed in the clamshell. Thus, the boom once per day rotation is accommodated by the Z axis gimbal and the X axis gimbal accommodates the clamshell north-south tracking of the sun. Both concepts allow residual rotational motions of the boom to perturb clamshell pointing. Hence, some potential for controller interactions exists in these control concepts. For this reason, concept 3 was developed.

2.5.3 **CONCEPT 3**

In concept 3, the clamshell control is made a full, 3 axis attitude control using the same LOS sensor as in concepts 2A and 2B but now adding a roll torque actuator and employing the roll reference error signal for roll axis control. Again, the control actuators are moment actuators modeled conceptually as force couples. In this concept, the booms are decoupled from the clamshells except for the gravity gradient force. This is accomplished by giving the hinges between boom and clamshells, full, 3 degrees of freedom. This prevents

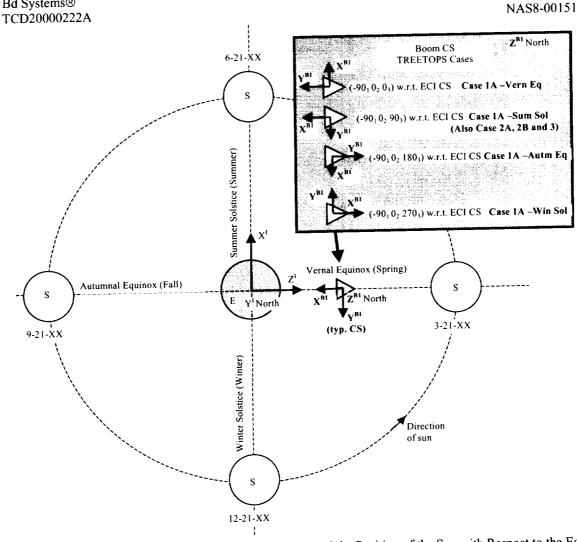


Figure 2.6.1: Body 1 (Boom) Initial CS wrt ECI CS and the Position of the Sun with Respect to the Earth at the Beginning of Each Season (Northern Hemisphere)(Plan View)

torques from being transferred between clamshells and boom and is the most robust ISC controller concept studied.

SIMULATION STUDIES: FOUR SEASONS AND EARTH SHADOW TRANSIENT 2.6 PASSAGE

The simulation studies performed on the ISC configuration and the various control concepts were run at various times of the year expected to represent the extremes for the gravity gradient and solar radiation pressure disturbances. These times are the transitional times between the 4 seasons, i.e. Vernal Equinox, Summer Solstice, Autumnal Equinox and Winter Solstice. The Vernal Equinox is the passage of the sun through the equatorial plane going from southern to northern celestial hemispheres and is the first day of spring in the Northern Hemisphere of Earth. The Summer Solstice is the maximum northward motion of the sun in the sky and is the first day of summer. The Autumnal Equinox is the passage of the sun through the equatorial plane going from northern to southern celestial hemispheres and is the first day of autumn or fall. The Winter Solstice is the southernmost motion of the sun in the sky and is the first day of winter. Figure 2.6.1 shows these positions in terms of motion of the sun with respect to the Earth. Figure 2.6.2 shows the same process in side view and represents relationship between the equatorial plane and the ecliptic plane. Also shown in figure 2.6.1 are the approximate dates in the year of the seasonal changes and the initial conditions appropriate for the boom angles in each of the control concepts. At the time of the equinoxes, the upper clamshell normal is pointed downward at 135° from north and the lower clamshell

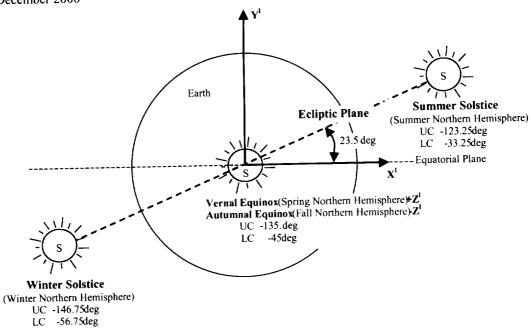


Figure 2.6.2: Position of the Sun with Respect to the Earth at the Beginning of Each Season (Elevation View). Inclination of Ecliptic plane relative to Equatorial plane.

normal is pointed upward at 45° from north. Figure 2.6.2 shows the clamshell angles at each of the seasons. The negative signs on these angles in the figure represents the sense of rotation required to properly position the clamshells. The clamshells redirect and concentrate the sunlight onto the upper and lower PV arrays respectively, with a 90° change of direction of the sunlight at the equinoxes and varying between 113.5 and 67.5 at the other seasons.

The transitions through the Earth's shadow were also studied. Near the equinoxes, the ISC passes through the Earth's shadow once per day. The period of passage lasts somewhat longer than one hour at its longest. This daily passage into the shadow occurs approximately from 1 month before to 1 month after the equinoxes with the duration of shadowing becoming shorter, going to zero when the sun exceeds 8.5° above or below the equatorial plane. The power beam radiation is accompanied by a thrust force of 7 N acting on the central body opposite the pointing direction of the beam, i.e. the negative central body X-axis. This thrust force persists as long as power is flowing in the beam and is appropriate to 2.1 gigawatts. Actual operational scenarios for shadow passage have not been defined but as a worst case condition it was assumed that there was insufficient storage to maintain the power transmission without direct sunlight. The power beam thrust force is cut off as the ISC passes into the Earth shadow and turned on again with passage out. These step force transitions with passage into and out of shadow were considered to be worst case for structure and control excitation. Examination of the Vernal and Autumnal Equinox simulations will reveal this effect. It is most visible in the disturbance forces and torques and the accelerometer sensor outputs.

2.7 CONTROL MOMENT GYROS (CMGS) VS. ION THRUSTERS

The control actuators were modeled in TREETOPS as moment actuators. These are most faithfully realized as pairs of thruster with equal and opposite thrusts at a finite moment arm, which is the perpendicular distance between the force lines of action. These thrusters are assumed to be ion thrusters having a specific impulse appropriate to such devices. Our guidelines for this study are to assume a specific impulse or I_{sp} of 2500 seconds. The moment arms are assumed to be the maximum dimension available in the appropriate axis on the structure being controlled. These assumptions will be employed to estimate the propellant required for control of the various concepts studied. As an alternative, some consideration is given here to momentum storage devices which we shall call CMG's for convenience. We

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recognize, however, that these may be momentum wheels or reaction wheels, single or double gimbal CMG's or other devices including flywheels used in the energy storage process. A literature search was performed in search of such devices and their state of development. Little was found, especially in the large size range considered appropriate for space solar power applications. International Space Station (ISS) size devices, approximately 3000 to 3500 Nms stored angular momentum, are considered a starting point size requirement for such systems. Periodic control torque levels in excess of 20,000 Nm with a periods of 12 and 24 hours are typical of levels required and there are occasional control torques in excess of 50,000 Nm. This implies 100,000 or more ISS size CMG's are required for each clamshell and a comparable number are required for central body control. Thus, approximately 300,000 units are required. Each has a mass in excess of 100 kg, so that the total CMG mass exceeds the mass of the ISC. It is clear from this top level discussion that development is required in this area to facilitate utilization of momentum storage technology. This extra structural weight must be traded with the logistical requirements for resupply of thruster propellants to maintain attitude control and stationkeeping. A supplementary consideration is the additional complexity of momentum management techniques required to maintain total stored angular momentum within storage requirements. Significant maneuvering of such a large structure for momentum management purposes would seem to be out of the question. Large scale magnetic torquing also seems impractical. Thus, thrusting for momentum dumping seems the most likely approach. Perhaps such momentum dumping thrust could be held to approximately 10% of that required to control entirely with thrusters. This would result in significant savings but since stationkeeping is also required and appears to be impossible using any other method than periodic thrusting, the value of momentum storage technology for control is reduced. Logistics for propellant resupply is still required.

3.0 RESULTS

It was considered essential to simulate a whole day of operation to assure that at least one cycle of the primary disturbances would be experienced by the systems. Typical simulation runs were 100,000 seconds. This allowed at least 15,000 seconds of time at the beginning of the run for initialization transients to decay so that the steady state motion could be studied. This study was not primarily interested in transient responses due to initialization errors but other transients such as passage through the Earth shadow were of interest because they were repetitive and sure to recur at regular intervals throughout the life of the ISC. Some simulations were run for times as long as 1,000,000 seconds primarily to study the shadow passage transient's longer-term effects. It was only possible to run a small number of such cases because the 10-12 hours of execution time required.

3.1 COMPARISON OF RESULTS FOR ALL CONTROL CONCEPTS OVER FOUR SEASONS -- SYNOPSIS

An extensive set of plots from all the simulation runs for the four control concepts run at each of the four seasonal transition dates is contained in Appendix B. Samples of the data will be discussed in this section to highlight the important results. The Summer Solstice simulations were the most extensively run. In the early phases of the study, all runs were made at this time because of our assessment that it was the time period of the worst case disturbances. Later, it was decided to examine the other seasonal transitions to balance the results and to get a broader sampling of the propellant usage over a typical year for a better estimate of annual totals. A comparison of control concept performance at Summer Solstice is available in section B.3- Figures B.3-1a, B.3-1b, B.3-1c, and B.3-1d show performance of the central body controller for each of the four concepts. Three of the four concepts yield acceptable error performances on the order of a few arc minutes or less. Concept 2A performance showing a yaw axis error repeatedly approaching 19 arc minutes which is marginal at best is shown in figure B.3-1b.. It is apparent from the frequency of the yaw axis error oscillation that boom yaw axis flexibility and the direct coupling of this to the clamshell moment of inertia is a principal factor An equally important factor is that the boom/central body hinge is attached at a point away from the central body center of mass. Thus, boom lateral oscillations couple into central body yaw rotational motion. Boom yaw axis control errors are shown in figure B.3-2a. There are no comparable plots for B.3-2b, etc. since the boom is rigidly attached to the central body in control concepts 2A, 2B and 3. Clamshell pointing errors are shown in figures B.3-3a through B.3-4d. Concept 1 shows a clamshell pointing error in excess of 15 arc minutes which is marginally acceptable. The series of plots in figures B.3-5a through B.3-5d shows the non-gravitational accelerations of the central body. This

vector quantity when multiplied by the total system mass of nearly 17,000 metric tons yields the value of the force that would be required to balance all disturbance forces for perfect stationkeeping control. This calculation yields the total thrust impulse for stationkeeping as determined in this study. The results of this calculation are shown later. Control torques are plotted in figures B.3-6a through B.3-9d for the Summer Solstice cases.

Control concept 1 was run at each of the 4 seasonal transition dates over the year. However, the initial conditions assigning pointing directions to the clamshells were recently discovered to be in error for all except Summer Solstice cases. Thus, results for VE, AE, and WS are not of value for calculating propellant usage. Since no controller is actively processing their error information, they were not being actively driven to proper pointing. This passive control, relying on open loop operation was the attractive feature for this concept, expected to reduce requirements for propellant and minimize complexity. The adverse aspect of the concept was the expected reduction in pointing accuracy and reliance on structural rigidity of the system and the control loads which were being transferred through the boom. Since the boom is extremely flexible in rotation about its slender axis, design of a controller acting in this degree of freedom must be extremely low gain so that the structure is not overstressed and no instabilities are created. In spite of the erroneous IC's behavior of the central body controller and the boom controller results are judged to still be of value. The nature of the initialization error at AE, WS, and VE is that yaw angle of the clamshells is 90°, 180°, or -90° from where they should be. This makes the calculations of solar radiation pressure and gravity gradient torques and the propellant required in error. No statements can be made relating to worst cases here. A valid technique here is to compare the SS results for concept 1 with SS results for concept 3.

The next section summarizes these results to estimate the amount of propellant required to maintain control of the ISC configuration for a year and provide stationkeeping.

THRUST REQUIREMENTS COMPARISON 3.2

The total propellant required for one year's operations is calculated in a series of tables presented as part of Appendix B. Table B.1-1 through B.1-4 presents results for concept 1. As stated above, the values presented as daily totals for AE, WS, and VE are not valid. Thus, the annual total is also not valid.

Table 3.2.1
Predicted Thrust Requirements for Concept 1, Concept 2A, Concept 2B,
Concept 3 and Stationkeeping

Description			Daily Total	WS	ave	Est. Annual Total ave x 365.25
	VE	SS	AE			
C1	97.	440.	101.	440.	270.	98475.
C2A	795.	1669.	808.	1637.	<u> 1227.</u>	448217.
	135.	478.	139.	480.	308.	112453.
C2B	133.	474.	137.	474.	305.	111243.
C3	133.	7/7.				
Custing language C1	389.	415.	400.	415.	405.	147917.
Stationkeeping C1	342.	376.	356.	376.	363.	132444.
Stationkeeping C2A			355.	376.	362.	132296.
Stationkeeping C2B	342.	375.			362.	132337.
Stationkeeping C3	342.	376.	355.	376.	302.	132337.

Notes

- See Table B.4-1
- Control based on predictions in tables B.1-5 (for C1), B.3-1 (for C2A), B.3-5 (for C2B) and B.2-1 (for C3) 1) 2)
- Stationkeeping baseed on predictions in tables B.1-6 (for C1), B.3-2 (for C2A), B.3-6 (for C2B) and B.2-2 (C3).

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However, SS results are valid. At the Summer Solstice, concept 1 requires 440 kg of propellant for pointing and attitude control and 415 kg are required for perfect stationkeeping control. Concept 3 requires 474 kg of propellant for pointing and attitude control and 376 kg for perfect stationkeeping. Since concept 1 results for AE, WS, and VE are not valid, estimates for usage over a year are made by prorating the SS usages to the other dates relative to concept 3 which is valid over all the dates. The same method is used for the other concepts 2A and 2B. Table 3.2.1 summarizes the results for propellant consumption for the four concepts. An additional point needs to be made with respect to stationkeeping estimates. Stationkeeping disturbance forces are assumed to be the same over all the concepts since they only depend on position and orientation of components, and these must be virtually the same for all concepts. The results in tables B.1-1 through B3-8 show that concepts 2A, 2B and 3 require virtually identical amounts of propellant while concept 1 requires a somewhat greater amount. This is related to the placement of the 3 axis accelerometer on body 1 at node 2 for concept 1 and on body 2 at node 2 for the other concepts. Nodes 2 on bodies 1 and 2 are constrained to be co-located. This forces the accelerations to be the same vectorially. However, body 1 in concept 1 is controlled to point to the sun while body 2 is controlled to point to the Earth. As a result, body 2 rotates once per day, while body 1 is non-rotating. The vector force required for stationkeeping is the same but it is resolved along two different axis systems. This makes the thruster forces which are assumed to be aligned with the coordinate axes different in the two cases. As an example to illustrate this, consider the case where the stationkeeping force is constant in the inertial frame, directed along one of the thrusters. In the second body, rotating once per day, the stationkeeping force varies sinusoidally along two of the thrusters. Comparing the two, one finds that the total propellant usage in the rotating body is $4/\pi$ times propellant usage in the stationary body. In the ISC stationkeeping case, the stationkeeping force is not constant in either inertial or rotating bodies so the problem is more complex. Our table of results show that concept 1 usage is approximately 10% higher than the other concepts. Based on this discussion it is clear that the 10% difference is due to the difference in the rotation state of the thrusting body. In this analysis, it was assumed that all stationkeeping thrust was applied at either the central body or the boom. A detailed design for stationkeeping would likely distribute the stationkeeping force as closely as possible to match the distribution of stationkeeping disturbances to minimize any structural deformations due to differential loading effects. It is assumed here that most of the solar pressure loading would be on the clamshells. If this were balanced by a stationkeeping force applied at the central body, a structural deformation of the boom would result.

Pointing and attitude control in TREETOPS is based on the use of force couples, which produce zero net force acting on the body being controlled. These thruster pairs are assumed to be separated by the maximum dimension available on the controlled body. Since two thrusters are firing at the same time, each separately contributes half the moment. Consequently, the appropriate moment arm to employ for propellant consumption calculations is half the maximum separation distance between thrusters. For example, the clamshell thruster moment arm is the clamshell radius which is taken from clamshell sketches as 1800m and from central body sketches as 500m. The moment arms must be divided into our control torque estimates to determine the thrust force required. In addition, the thruster's specific impulse or I_{sp} also must be divided into the thrust force to calculate the weight flow rate of propellant in N/s which in turn must be divided by g = 9.81 m/s to calculate kg/s of propellant flow. Our guidelines for this study were to use 2500 sec as the thruster specific impulse appropriate to expected ion thruster level of technology available for the ISC. The above calculations employed these assumptions.

As a secondary consideration, it is worth noting that our calculations of total propellant required for control and stationkeeping assume no advantage is taken of opportunities to combine these processes. This is quite conservative. For example, consider the case where stationkeeping requires a force along X of 50N and pointing and attitude control requires a pair of thrusters firing at 25N along + and – X respectively. A single thruster producing 50N along + X could simultaneously satisfy both requirements if placed at the position of the pointing and attitude control 25N thruster with no additional use of propellant for stationkeeping. It is probable that most or all of the stationkeeping force could be combined with attitude and pointing control. Alternatively, it may not be necessary to continuously balance the stationkeeping acceleration forces. Half a degree of error in geosynchronous orbit position is allowed before any correction is required and since much of the stationkeeping accelerations are periodic, much of the stationkeeping drift may balance over time. Thus, the total propellant usage will be strongly dominated by attitude and pointing control requirements. More study of this phenomenon is required to more accurately

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estimate its impact on propellant usage. Our scope does not permit us to delve into this phenomenon. Interestingly, our results indicate that pointing/attitude control and stationkeeping propellant requirements when considered separately are roughly equal. Thus, we can probably combine the requirements for both by taking the larger of the two and adding 10%. It appears to be quite conservative to take the two separately and add. Perhaps for now that is the thing to do until more study reveals better estimates.

From the previous discussion, the SS propellant daily total for control and stationkeeping in concepts 1 and 3 were each approximately 850 kg. Concept 3 annual consumption is most accurately calculated over the year and according to tables B.2-3 and B.2-4 in Appendix B yields an annual total of 243,600 kg or 244 metric tons. We can infer from the above that concept 1 propellant usage is the same. <<<<re>rewrite>>>>

3.3 WEIGHT REQUIREMENTS COMPARISON

Propellant does not appear to be a significant discriminating factor in the weight considerations. The primary differences between concepts for weight considerations is the number of degrees of freedom at hinges H2, H3 and H4. Recall that H2 is the hinge between the central body and the boom and that H3 and H4 are the connections between the boom and the two clamshells. Concept I may require a simpler hinge structure at H3 and H4 but will likely more than make up for this simplicity by the complexity and weight of the actuator structure required at H2. Concept 2A has been identified as unacceptable because of the rotational motion induced on the clamshells about their surface normals as well as the unacceptable pointing oscillation and related propellant usage shown above. Concept 2B, which is a modest variation of the 2 degrees of freedom at hinges H3 and H4 from concept 2A, produces significantly better performance than 2A and propellant consumption that is comparable to 1A and 3. Overall there does not appear to be a significant weight differentiation between acceptable control concepts.

3.4 IMPLEMENTATION COMPLEXITY COMPARISON

Concept 3 appears to be the most complex control concept defined in this study since it has more axes being controlled. Examination of the control performance indicates that it also produces the best overall performance of all the concepts. In addition, it produces the least loading on the boom, isolating it from any disturbance torques from the clamshell. In our model, no frictional torques were generated at hinges H3 or H4. The realization of such a hinge may require actively controlled devices such as magnetic suspension. The loads required to be supported at these joints appear to be modest, perhaps of the order of 100-200 N. Adjusting to include a safety factor may drive this to 500N. This would appear to be within achievable levels of magnetic bearing technology, though perhaps other technologies should be examined.

Sensor requirements would appear to be within present state of the art for star trackers and sun sensors. The LOS sensor assumed for pointing the clamshells could be realized by combinations of these devices or perhaps a sun sensor measuring the position of the sun and an artificial star on the PV array being tracked by a tracker on the clamshell. Roll error sensing requirements would be quite modest for this operation. Our controllers were purposely made quite simple, not applying any pressure to the boundaries of control state of the art.

3.5 OVERALL ASSESSMENT COMPARISON

It appears that control of the ISC configuration is feasible as long as ion thrusters of sufficient size for stationkeeping application are available. This implies thruster of several Newtons in thrust and throttleable, although the throttling effect may be achieved by turning on or off individual thrusters in large clusters of these devices. The plumbing requirements for such a system may be a challenging problem, especially the inclusion of the necessary redundancy. Of the control concepts studied, concept 1 is the simplest and concept 3 is the overall best. It does not appear that concept 1 is sufficiently simpler nor uses sufficiently less propellant to be judged preferable. Concept 3 has the best performance, therefore the most margin and seems to present the least risk.

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4.0 SUMMARY AND CONCLUSIONS

The Integrated Symmetrical Concentrator Space Solar Power Satellite configuration has been analyzed and simulated in a multi-body, flexible body analysis. This analysis and simulation included the effects of body structural flexibility, gravitation and solar radiation pressure disturbances. Four control concepts were developed and implemented for this configuration.

4.1 **CONTROLLERS**

The controllers developed for the ISC configuration were conventional and analog in their implementation. Angular position sensors were used to compute errors and analytically derived rates based on the sensed errors were used in PD (position and derivative) feedback linear controllers. These controllers employing moment actuators on the controlled bodies were implemented through the built-in TREETOPS linear control architecture. The input files that accomplish this are included in Appendix A. Issues related to discrete processes and sampling were bypassed and ignored by the assumption of continuous, analog control. Digital implementation and related issues are not expected to be a problem as these techniques have been standard for many years and such issues are well understood. Controllers were purposely kept simple and basic to preclude concerns related to realizability. No consideration was given to problems related to construction or erection of the ISC system into POP attitude, though this is expected to be a considerable problem in its own right. Also, no consideration was given to maneuvers and little consideration to transient responses. Initialization transients were present in most simulation runs and inadvertent errors in initialization revealed robust behavior in most cases in ability to take out such errors though the torques required to do so were in many instances unrealistically high since no limiting was applied to the actuators. Complete results in plot form are contained in Appendix B.

4.2 MODELS

The principal analysis tool employed for this study is an enhanced form of the multi-body analysis and simulation code TREETOPS. This has been enhanced as explained elsewhere in this report body. Three of the four bodies in the ISC model were treated as rigid. The fourth, the long slender boom used as the metering structure for the clamshells, was modeled in its flexibility. A Nastran model was developed for this purpose. The flexible mode frequencies are presented in appendix C for the boom in various loaded conditions as defined by TREETOPS, which calculated an appropriate mass and stiffness matrix from the inputs. The details of the Nastran model are presented in Appendix D.

4.3 DISTURBANCES

The enhanced TREETOPS provides for detailed modeling of gravitational forces and moments as well as for solar radiation pressure. Additionally, included in TREETOPS though not considered significant for this study are aerodynamics and magnetic fields. A full gravity model is implemented supplementing the circular and near circular orbit models previously available. The gravity enhancement included a treatment of flexible body loading, which was previously ignored. Power beam radiation force was also included because of its potential for significant transients as it is turned off and on and also for its ability to contribute to the stationkeeping disturbance environment.

4.4 FEASIBILITY ISSUES

Feasibility of the control concepts studied in this report seems to be virtually assured by the conservative and conventional nature of the controllers defined. Perhaps the biggest question would be the feasibility of producing sufficiently large ion thrusters and gathering and storing sufficient propellant to drive them. Questions related to alternative control methodologies such as momentum management exist related to feasibility and these have been discussed in the report. In summary, momentum management techniques would seem to offer only marginal ability to reduce propellant required and would not seem to offer any significant opportunities to save weight. In fact, additional weight appears to be required and/or considerable development to achieve efficiencies in momentum storage perhaps through combining

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Momentum storage with flywheel energy storage may offer some hope. Current literature does not seem to
Offer much hope here.

5.0 FUTURE WORK

As the ISC or other configurations are carried forward into more detailed designs, opportunities exist to revisit and enhance the control concepts developed in this study or to add new ones. Significant issues related to construction/erection of the ISC and the dynamics associated with resupply and routine maintenance are fertile areas for analysis and modeling. Greater fidelity in the modeling process, more consideration of body flexibility are other areas of future work and study. Digital control/sampling effects may be added and more exotic controllers are other areas for future study when the number of configurations is narrowed and the geometry and mass properties are better known and firmed up. Combined effects due to thermal heating and cooling and structural interactions are also areas needing study.

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Appendix A

TREETOPS Model Descriptions

TREETOPS model descriptions of the SSP ISC Configuration for concept 1, concept 2A, concept 2B and concept 3 are given herein. Specifically, the following files are provided herein.

INPUT:

.int file – Problem Definition (data entered using TREESET)
define bodies, hinges, sensors, actuators, interconnects, etc.
.lin file – Defines the A, B, C, D matrix for

xdot = Ax + Buy = Cx + Du

los.dat - Used for locating a los vector between two star position vectors solar_pressure.dat - Solar Pressure Definition: body, node, area, reflectivity factor, outward normal, centroid

.flx file – Flex data file [SSP Boom (Body 1) modeled as flexible]

An excerpt is given herein. A full flex file is provided in delivered data package.

OUTPUT:

.CRF file - Cross-reference variables (used to interpret results)
.MAT file - TREETOPS matrix format data file (read into MATLAB) not given here, but provided in delivered data package

This appendix is organized as follows:

First, some general figures and tables are given. Then, information specific to each concept is given.

A.1 Concept 1 Definitions and TREETOPS files

Sensor Definitions

Actuator Definitions

Interconnect Definitions

TREETOPS files:

Summer Solstice (SS): .int, .lin, los.dat, solar_pressure.dat, excerpt of .flx

Vernal Equinox (VE): .int Autumnal Equinox (AE): .int Winter Solstice (WS): .int

A.2 Concept 2A Definitions and TREETOPS files

Sensor Definitions

Actuator Definitions

Interconnect Definitions

TREETOPS files:

Summer Solstice (SS): .int, .lin, los.dat, solar_pressure.dat, excerpt of .flx

A.3 Concept 2B Definitions and TREETOPS files

Sensor Definitions

Actuator Definitions
Interconnect Definitions

TREETOPS files:

Summer Solstice (SS): .int, .lin, los.dat, solar_pressure.dat, excerpt of .flx

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A.4 Concept 3 Definitions and TREETOPS files

Sensor Definitions
Actuator Definitions
Interconnect Definitions
TREETOPS files:

Summer Solstice (SS): .int, .lin, los.dat, solar_pressure.dat, excerpt of .flx

Vernal Equinox (VE): .int Autumnal Equinox (AE): .int Winter Solstice (WS): .int

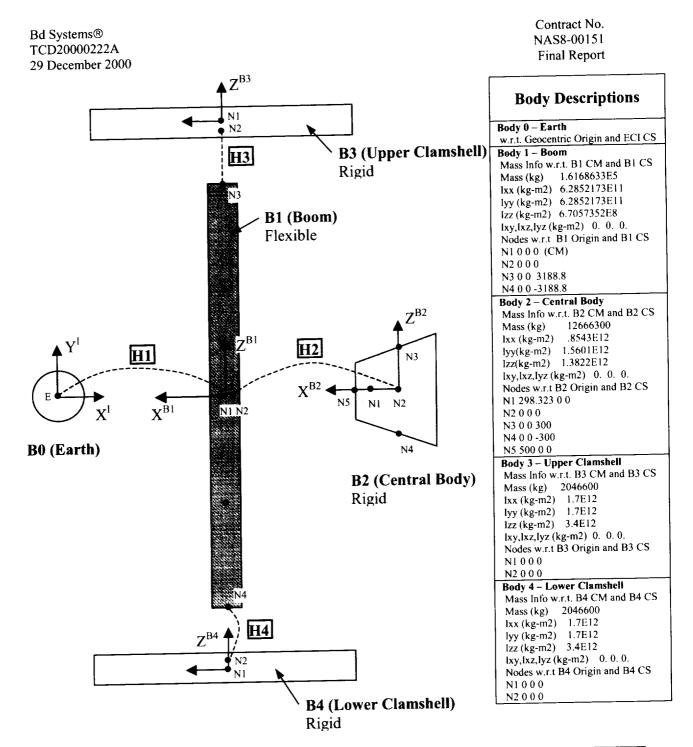
In order to edit TREETOPS use treesel.bat.. For example,

treesel.bat isc3_flex_sol

In order to run TREETOPS use treetops.bat. For example

treetops.bat isc3_flex_sol

A graphical sketch of the TREETOPS model of the SSP ISC configuration is provided in Figure A.1 for convenience. The TREETOPS inertial coordinate system is given in Figure A.2. A typical TREETOPS body 1 (boom) coordinate system at vernal equinox, typical boom orientation for case 1 SS, case 2A, 2B and 3, is given in Figure A.3. The body 1 (boom) initial coordinate system with respect to the earth centered inertial coordinate system (ECI CS) and the position of the sun with respect to the earth at the beginning of each season (northern hemisphere)(plan view) is given in Figure A.4. The position of the sun with respect to the earth at the beginning of each season (northern hemisphere) (elevation view) is given in Figure A.5. The initial condition pitch angles of the upper and lower clamshells is given in Figure A.6. The initial conditions in TREETOPS for body 1 (boom), body 2 (central body), body 3 (upper clamshell), and body 4 (lower clamshell) for concept 1, concept 2A, concept 2B and concept 3 are given in Tables A.1a and A.1b. (Later, it was realized that the initial conditions for body 3 and 4 (UC and LC) for concept 1 VE, AE, and WS were not entirely correct. For concept 1 VE, AE and WS, the initial conditions for UC and LC pitch angle were correct, but the initial condition for the UC and LC yaw angle with respect to the boom was not correct.)



			112	H4
Description	H1	H2	<u>H3</u>	114
ļ	$3-L1(X^{1}),L2(Y^{1}),L3(Z^{1})$	1- L1(Z ^{B1})	0	0
Concept 1		(/	2 11(VB) 12(VB)	$2-L1(X^{B1}),L2(Y^{B1})$
Concept 2A	$3-L1(X^{1}),L2(Y^{1}),L3(Z^{1})$	0		·
	$3-L1(X^{1}),L2(Y^{1}),L3(Z^{1})$	0	$2-L1(Z^{B1}),L2(X^{B1})$	$2-L1(Z^{B1}),L2(X^{B1})$
Concept 2B		<u> </u>		$3-L1(Z^{B1}),L2(X^{B1}),L3(Y^{B1})$
Concent 3	$3-L1(X^{1}),L2(Y^{1}),L3(Z^{1})$	0	$3-L1(Z^{B1}),L2(X^{B1}),L3(Y^{B1})$	3º E1(2); E2(1); 23(1)

Figure A.1: TREETOPS Model of SSP Integrated Symmetrical Concentrator

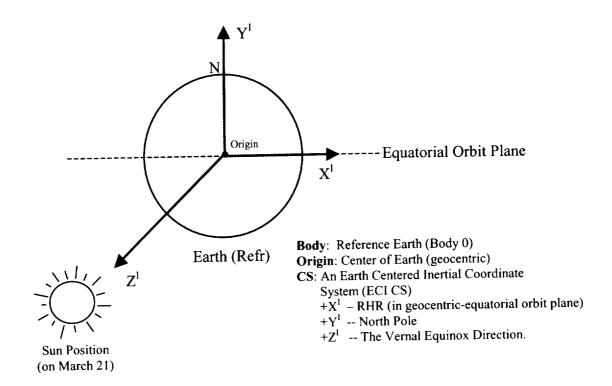


Figure A.2: TREETOPS Inertial Coordinate System

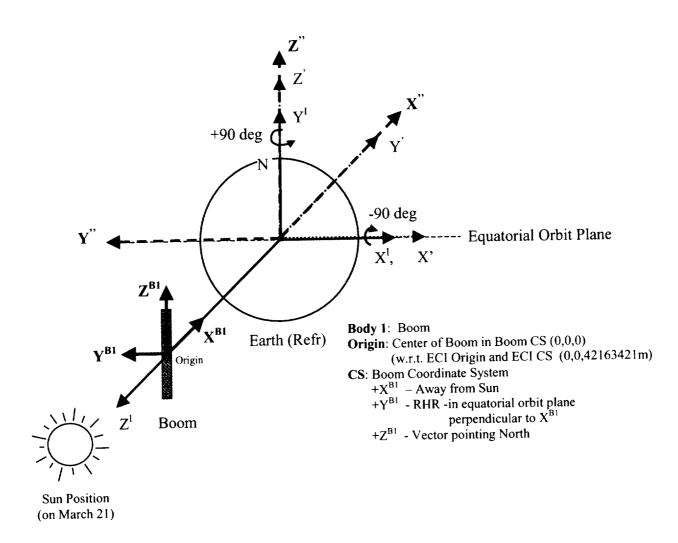


Figure A.3: Typical TREETOPS Body 1 (Boom) Coordinate System at Vernal Equinox (Typical Boom Orientation for Case 1 SS, Case 2A, 2B and 3)

Boom CS at Vernal Equinox = [90]₃[0]₂[-90]₁ * ECI CS

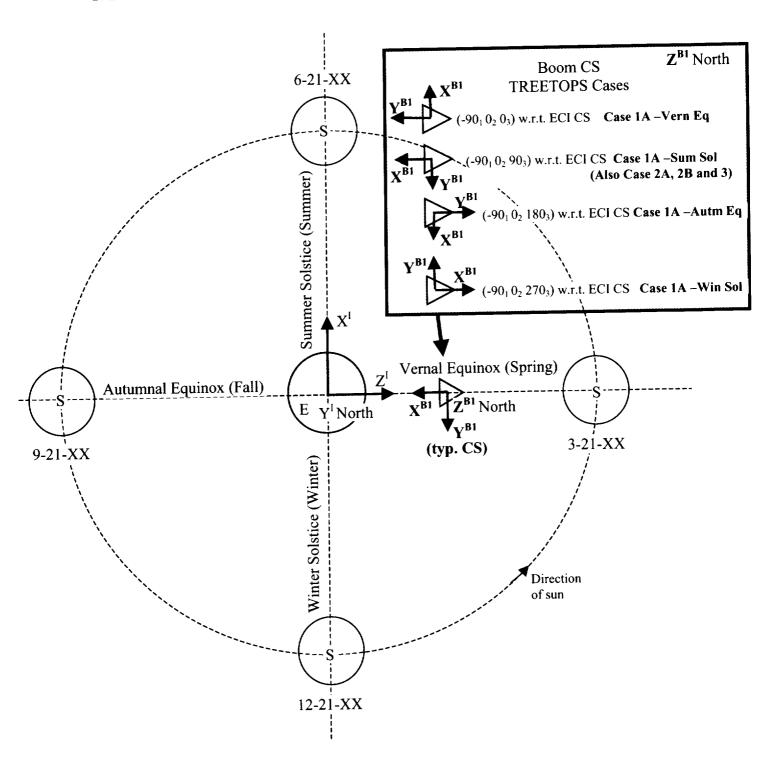


Figure A.4: Body 1 (Boom) Initial Coordinate System with respect to the Earth Centered Inertial Coordinate System (ECI CS) and the Position of the Sun with Respect to the Earth at the Beginning of Each Season (Northern Hemisphere)(Plan View)

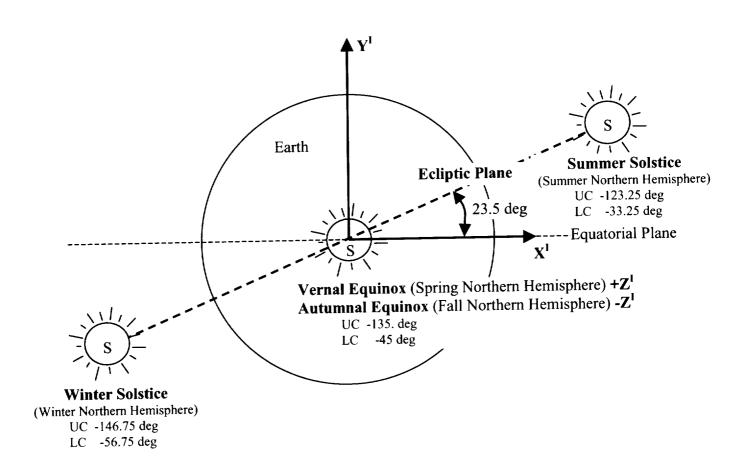


Figure A.5: Position of the Sun with Respect to the Earth at the Beginning of Each Season (Northern Hemisphere) (Elevation View)

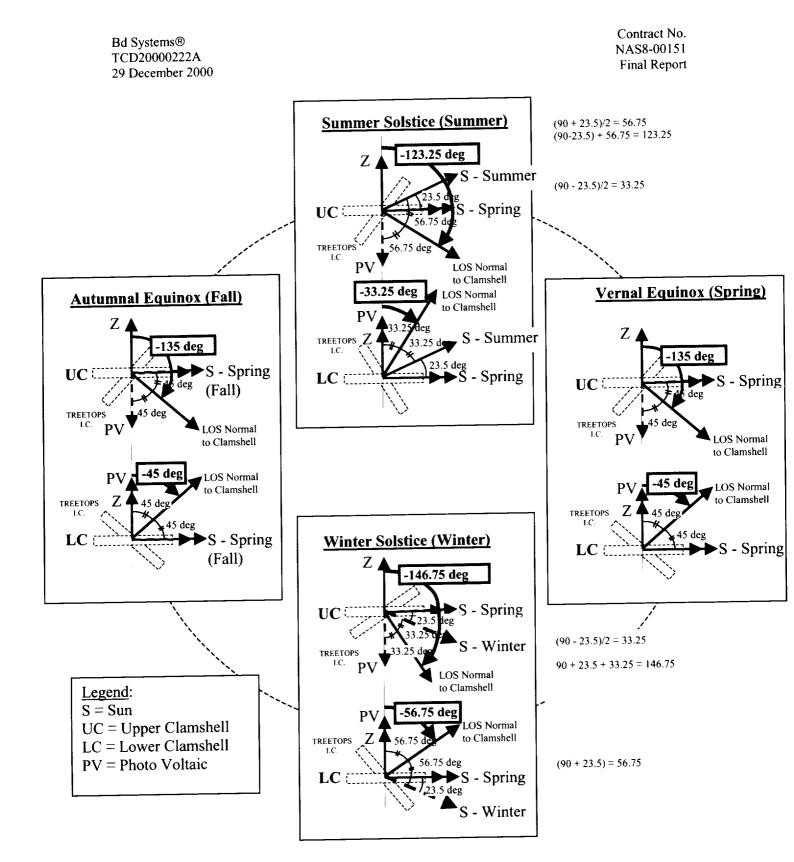


Figure A.6: Initial Condition Pitch Angles of the Upper and Lower Clamshells

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	Tab	ole A.1a: Initial C Concept	Initial Conditions in TREETOPS for Body 1 (Boom Concept 1, Concept 2A, Concept 2B and Concept 3	n TREET it 2A, Cor	OPS for I	Body 1 (I and Conc	Soom) and	Table A.1a: Initial Conditions in TREETOPS for Body 1 (Boom) and Body 2 (Central Body) Concept 1, Concept 2A, Concept 2B and Concept 3	Body)			
		Body 1 (Boom -Fle	om –Flexil	xible)				Body 2 (Central Body – Rigid)	tral Body	– Rigic	(1)	
	Н		Initial Euler Rotation Angles	Initial Rotation Rate	Initial Translation	Initial Translation Velocity	H2 Free Rotational DOF		Initial Euler Rotation	Initial Rotation Rate	Initial Translation	Initial Translation Velocity
Description	Free Rotational DOF between Body 0 (Earth) & Body 1 (Boom)	Reference axis for Euler Angles	(deg) w.r.t geocentric origin in ECI CS	(deg/sec) w.r.t geocentric origin in ECI CS	(m) w.r.t. geocentric origin in ECI CS	(m/sec) w.r.t. geocentric origin in ECI CS	between Body I (Boom) & Body 2 (Central Body)	Reference axis for Euler Angles	Angles (deg) w.r.t boom origin in boom CS	(deg/sec) w.r.t boom onigin in boom	w.r.t. boom origin in boom CS	w.r.t. boom origin in boom
Concept 1			1 1	1 1				ri e				
Vern Eq	3 - L1(X'), L2(Y'), L3(Z')	L1(X'),L2(Y'),L3(Z')	-90.0. 0.	(0 0 0.)	(0. 0. R)	(v 0. 0.)	1- L1(2°)	$L1(Z^{B})L2(Y^{B})L3(X^{B})$	90.0.0	(B)	(0, 0, 0, 0)	; ;
Autm Eq	3-L1(X ¹),L2(Y ¹),L3(Z ¹)	L1(X ¹),L2(Y ¹),L3(Z ¹)	1-		ن ا		1- L1(Z ^B)	$L1(Z^B),L2(Y^B),L3(X^B)$	-90.0.0.	(a)	(0.0.0)	1
Win Sol	$3-L1(X^1),L2(Y^1),L3(Z^1)$	$L1(X^1),L2(Y^1),L3(Z^1)$	-90. 0. 270.	(0. 0. 0.)	(0. 0. R)	(v 0. 0.)	$1 - L1(Z^B)$	$L1(Z^B),L2(Y^B),L3(X^B)$	180.0.0.	(ω)	(0.0.0)	1
Concept 2A											!	
Vern Eq	$3 - L1(X^1), L2(Y^1), L3(Z^1)$	$LI(X^1),L2(Y^1),L3(Z^1)$	-90.0. 90.	(0. 0. ω)	(0. 0. R)	(v 0. 0.)	0	$L1(Z^B),L2(Y^B),L3(X^B)$	0.0.0	:	(0.0.0)	1
Sum Sol	$3 - L1(X^1), L2(Y^1), L3(Z^1)$	$[L1(X^{l}),L2(Y^{l}),L3(Z^{l})]$	-90.0.90.	(0. 0. w)	(0. 0. R)	(v 0. 0.)	0	$L1(\mathbb{Z}^{B}),L2(\mathbb{Y}^{B}),L3(\mathbb{X}^{B})$	0.0.0	+	(0.0.0.)	1
Autm Eq	$3 \cdot L1(X^1), L2(Y^1), L3(Z^1)$	$L1(X^1),L2(Y^1),L3(Z^1)$	-90. 0. 90.	(0. 0. w)	(0. 0. R)	(v 0. 0.)	0	$L1(\mathbb{Z}^B),L2(\mathbb{Y}^B),L3(\mathbb{X}^B)$	0.0.0	-	(0.0.0)	1
Win Sol	$3 - L1(X^1), L2(Y^1), L3(Z^1)$	$L1(X^1),L2(Y^1),L3(Z^1)$	-90.0. 90.	(0. 0. w)	(0. 0. R)	(v 0. 0.)	0	$\begin{bmatrix} L1(\mathbf{Z}^{\mathbf{B}}),L2(\mathbf{Y}^{\mathbf{B}}),L3(\mathbf{X}^{\mathbf{B}}) \end{bmatrix}$	0.0.0		(0.0.0)	;
Concept 2B			1 1									
Vern Eq	$3-L1(X^1),L2(Y^1),L3(Z^1)$	$L1(X^{i}),L2(Y^{i}),L3(Z^{i})$		(0. 0. ω)	(0. 0. R)	(v 0. 0.)	0	$L1(Z^b),L2(Y^b),L3(X^b)$	0.0.0	;	(0.0.0)	1
Sum Sol	$3 - L1(X^1), L2(Y^1), L3(Z^1)$	$[L1(X^{l}),L2(Y^{l}),L3(Z^{l})]$		(0. 0. w)	(0. 0. R)	(v 0. 0.)	0	$[L1(Z^B),L2(Y^B),L3(X^B)]$	0.0.0	;	(0.0.0)	:
Autm Eq	$3 - L1(X^1), L2(Y^1), L3(Z^1)$	$[L1(X^{l}),L2(Y^{l}),L3(Z^{l})]$	-90.0.90.	(0. 0. ω)	(0. 0. R)	(v 0. 0.)	0	$L1(Z^B),L2(Y^B),L3(X^B)$	0. 0. 0.	-	(0.0.0)	-
Win Sol	$3 - L1(X^1), L2(Y^1), L3(Z^1)$	$[L1(X^1),L2(Y^1),L3(Z^1)]$	-90.0. 90.	(0. 0. w)	(0. 0. R)	(v 0. 0.)	0	$L1(Z^B),L2(Y^B),L3(X^B)$	0.0.0	1	(0.0.0)	;
Concept 2C												
Vern Eq	$3-L1(X^1),L2(Y^1),L3(Z^1)$	$L1(X^{l}),L2(Y^{l}),L3(Z^{l})$	-90.0.90.	(0. 0. w)	(0, 0, R)	(v 0. 0.)	0	$L1(Z^{B}),L2(Y^{B}),L3(X^{B})$	0.0.0	:	(0.0.0)	1
Sum Sol	$3 - L1(X^1), L2(Y^1), L3(Z^1)$	$[L1(X^{1}),L2(Y^{1}),L3(Z^{1})]$	1 1	(0, 0, ω)	(0. 0. R)	(v 0. 0.)	0	$[L1(Z^{B}),L2(Y^{B}),L3(X^{B})]$	0.0.0	:	(0.0.0)	:
Autm Eq	$3 - L1(X^1), L2(Y^1), L3(Z^1)$	$[L1(X^{l}),L2(Y^{l}),L3(Z^{l})]$	-90.0.90.	(0. 0. w)	(0. 0. R)	(v 0. 0.)	0	$L1(Z^B),L2(Y^B),L3(X^B)$	0.0.0	:	(0.0.0)	;
Win Sol	$3 - L1(X^1), L2(Y^1), L3(Z^1)$	$L1(X^1),L2(Y^1),L3(Z^1)$	-90.0.90.	(0. 0. w)	(0. 0. R)	(v 0. 0.)	0	$L1(Z^B),L2(Y^B),L3(X^B)$	0.0.0	1	(0.0.0)	!
Notes										73-1	-ECI CS B-B1-	J
1) Constant	1) Constants Used in Table:	à								ーEし	1C3 D-D1-	B-B1-B00m C3

¹⁾ Constants Used in Table: ω = [1 + (1/365.25)][360 deg/(24hrx3600 sec/hr)]=.004178 deg/sec R = 42163421. m v = 2πR/86161.975 = 3074.681 m/sec

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	Table A.1	Table A.1b: Initial Conditions in TRI Concept 2A, 0	ons in TREE Icept 2A, Cor	FOPS for	EETOPS for Body 3 (Uppe Concept 2B and Concept 3	(Upper Cla	ımshell) and	EETOPS for Body 3 (Upper Clamshell) and Body 4 (Lower Clamshell) Concept 2B and Concept 3	Clamshell)		
	Bo	Body 3 (Upper Clamshell - Rigid)	mshell - Rigi	d			Bod	Body 4 (Lower Clamshell – Rigid)	mshell – Rigi	(p	
Description	H3 Free Rotational DOF Body J. (Booth) &	Reference axis for Euler Angles	Initial Euler Rotation Angles (deg) w.r.t boom origin m boom CS	Initial Rotation Rate (deg/sec) w.r.t boom origin in boom CS	Initial Translation (m) w.r.t. boom origin in boom	Rotation No. 1 Rotation No. 1 Rody 1 V Body 1 (L) Body 1 (L)	Free Rotational DOF between Body 1 (Boom) & Body 4 (Lower Clarmshell)	Reference axis for Euler Angles	Initial Euler Rotation Angles (deg) w.r.t. boom origin in boom CS	Initial Rotation Rate (deg/scc) w.r.t boom ongin in boom	Initial Trans- lation (m) w.r.t. boom T origin N origin
	(managed of fron				S						
Concept 1		e e					-	(8Y) E 1 (8X) C 1 (8Z) 1 1	Q 0 45	;	(0.0.0)
Vem Eq	0	$L1(Z^{B}), L2(X^{B}), L3(Y^{B})$	90 0 -133.	: ;	(0.0.0.)		0	$L1(Z^B), L2(X^B), L3(Y^B)$	1 1	-	(0.0.0)
Sum Sol		$(1/7^{B}) (1/7^{B}) (1/7^{B}) (1/7^{B})$:	(0.0.0)		0	$L1(\mathbb{Z}^B),L2(\mathbb{X}^B),L3(\mathbb{Y}^B)$		1	(0.0.0)
Win Sol	0	$L1(Z^{B}), L2(X^{B}), L3(Y^{B})$	-90. 0146.75	-	(0.0.0)		0	$L1(Z^{B}),L2(X^{B}),L3(Y^{B})$	96. 0. –56.75	1	(0.0.0)
Concept 2A					,		VB I SAVB	11(VB) 13(VB) 13(7B)	0 45 0	(0 0)	(0.0.0)
Vern Eq	$2 - L1(X^B), L2(Y^B)$	$L1(X^B), L2(Y^B), L3(Z^B)$	135	(0. 0)	(0.0.0.)	_	$2 - L1(X^2), L2(Y^2)$	L1(A), L2(1), L3(2)	25 0.		(0.0.0)
Sum Sol	$2 - L1(X^B), L2(Y^B)$	$L1(X^{B}), L2(Y^{B}), L3(Z^{B})$	0 135 0.0.	(0. 0.)	(0.0.0)	2- L1()	$\frac{2}{2} \cdot L1(X^B), L2(Y^B)$	$L1(X^B),L2(Y^B),L3(Z^B)$	45		(0.0.0)
Autm Eq Win Sol	$2 \cdot L1(X^B), L2(Y^B)$	$L1(X^B), L2(Y^B), L3(Z^B)$	75 0		(0.0.0)	- 2-L1C	2- L1(X ^B),L2(Y ^B)	$L1(X^B),L2(Y^B),L3(Z^B)$	-56.75 0. 0.	(0. 0.)	(0.0.0)
Concept 2B					(,	7B, 1 3/VB,	11(78)17(VB)13(VB)	-90 45 0	(0 0 -)	- (0.0.0)
Vет Eq	$2-L1(Z^B),L2(X^B)$	$L1(Z^{B}),L2(X^{B}),L3(Y^{B})$	-90. 135. 0.	(-m 0.)	(0.0.0)		$2 \cdot L(Z^B) \cdot L(A)$	$11(2^{B})12(X),L3(1)$	12	(-0.0)	(0.0.0)
Sum Sol	$2 \cdot L1(Z^B), L2(X^B)$	$L1(Z^B), L2(X^B), L3(Y^B)$	0. 123.25 0.	(-e 0.)	(0.0.0.)	2-11($\frac{2-L1(2),L2(A)}{2-L1(7^B)}$	$L1(Z^B), L2(X^B), L3(Y^B)$	90. 45. 0.	(-0 0·)	(0.0.0)
Autm Eq Win Sol	$2 \cdot L1(Z^{B}), L2(X^{B})$ $2 \cdot L1(Z^{B}), L2(X^{B})$	$L1(Z^{B}), L2(X^{B}), L3(Y^{B})$	75	(-m 0.)	(0.0.0.)		2- L1(Z ^B),L2(X ^B)	$L1(Z^B), L2(X^B), L3(Y^B)$	180. 56.75 0.	(-@ O.)	(0.0.0)
Concept 2C		c				-	2 11(7B) 12(VB) 12(VB)	11/78/12/VB/13/VB	0 0 45	(0 0 0-)	(0.0.0)
Vern Eq	$3 \cdot L(Z^B), L2(X^B), L3(Y^B)$	$L1(Z^{B}),L2(X^{B}),L3(Y^{B})$	0.0135.	(-0 0.0.)	(0.0.0.)	- 3- L1(Z ^B).	$3 - L1(Z^B) L2(X^B) L3(Y^B)$	$L1(Z^B), L2(X^B), L3(Y^B)$		(-0 0.0°)	(0.0.0)
Sum Sol Autm Fo	3- $L1(Z^{B}), L2(X^{B}), L3(Y^{B})$	$L1(Z^B), L2(X^B), L3(Y^B)$	180. 0. –135.	(-0 0.0.)	(0.0.0.)	$-3-\text{L1}(Z^B)$	$3-L1(Z^B),L2(X^B),L3(Y^B)$	$L1(Z^B),L2(X^B),L3(Y^B)$		(-m 0. 0.)	\dashv
Win Sol	3-L1(Z ^B),L2(X ^B),L3(Y ^B)	+	-90. 0146.75	(-m 0. 0.)	(0.0.0.)	- 3-L1(Z ^B),	$3-L1(Z^B),L2(X^B),L3(Y^B)$	$L1(Z^B),L2(X^B),L3(Y^B)$	-90. 056.75	(-m 0. 0.)	- (0.0.0.0)
Notes (1) Constant	otes 1) Constants Used in Table:									I=ECI CS B=	B=B1=Boom CS

Constants Used in Table::
 α = [1 + (1/365.25)][360 deg/(24hrx3600 sec/hr)]=.004178 deg/sec:
 R = 42163421. m;
 v = 2πR/86161.975 = 3074.681 m/sec
 in Figure 1 initial Translation Velocity (m/sec) w.r.t. boom origin in boom CS
 iTV - Initial Translation Velocity (m/sec) w.r.t. boom origin in boom CS
 in reference to crossed-out numbers above, it was later determined that the initial condition for Concept 1 L1(Z^B) should have been 90 deg for all cases.

A.1 Concept 1 Definitions and TREETOPS files

Sensor Definitions Actuator Definitions Interconnect Definitions TREETOPS files:

Summer Solstice (SS): .int, .lin, los.dat, solar_pressure.dat, excerpt of .flx

Vernal Equinox (VE): .int Autumnal Equinox (AE): .int Winter Solstice (WS): .int

		T	ableA.1	.1 Sensor Definiti	ons (Concept 1)
Global Sensor Output	TREETOPS Sensor	Local Sensor Output	Sensor Mount Loc.	Туре	u s c d
No.	Designation	No.	B2-N2	Earth Target (ET)	Pitch (Y ^{B2}) Error - Overall System (Central Body)
RP I	SE 1	1 1		(LOS Along X ^{B2})	Yaw (Z ^{B2}) Error – Overall System (Central Body)
RP 2	SE 1	2	B2-N2	Star Tracker (ST)	Roll (X ^{B2}) Error – Overall System (Central Body)
RP3	SE 2	1	B2-N2	(LOS Along Z ^{B2})	Not used in control (Pitch (Y ^{B2}) Error) Central Body
RP4	SE 2	2	B2-N2	(LOS Along Z)	Not used in control (Validity Flag on(1) off(0))
RP 5	SE 2	3	B2-N2	Con Transland (CT)	Yaw (Z ^{B1}) Error – Boom
RP 6	SE 3	1	B1-N2	Star Tracker (ST) (LOS Along Y ^{B1})	Not used in control, Roll (X ^{BI}) Error – Boom
RP 7	SE 3	2	B1-N2	(LOS Along 1)	Validity Flag on(1) off(0) Used for Rad Pres Disturb
RP8	SE 3	3	B1-N2	2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Not used in control, For Output Only, ACCEL (X ^{BI})
RP9	SE 4	1	B1-N2	3 Axis Accelerometer	Not used in control, For Output Only, ACCEL (Y ^{BI})
RP 10	SE 4	2	B1-N2	(A3) with gravity removed	Not used in control, For Output Only, ACCEL (Z ^{BI})
RP 11	SE 4	3	B1N2	gravity removed	Not used in control, For Output Only, DCM (1,1)
RP 12	SE 5	1	B1-N2		Not used in control, For Output Only, DCM (1,1) Not used in control, For Output Only, DCM (2,1)
RP 13	SE 5	2	B1-N2		Not used in control, For Output Only, DCM (2,1) Not used in control, For Output Only, DCM (3,1)
RP 14	SE 5	3	B1-N2	Local Vertical (LV)	Not used in control, For Output Only, DCM (1,2)
RP 15	SE 5	4	B1-N2	BJ_LVLH Transform Columns (Direction	Not used in control, For Output Only, DCM (2,2)
RP 16	SE 5	5	B1-N2	Cosine Matrix)	Not used in control, For Output Only, DCM (2,2) Not used in control, For Output Only, DCM (3,2)
RP 17	SE 5	6	B1-N2	Cosine Mana	Not used in control, For Output Only, DCM (1,3)
RP 18	SE 5	7	B1-N2		Not used in control, For Output Only, DCM (2,3)
RP 19	SE 5	- 8	B1-N2		Not used in control, For Output Only, DCM (3,3)
RP 20	SE 5	9	B1-N2		Not used in control, Pol Output Only, Bell (3,5) Not used in control, Roll (X ^B) Error –UC
RP 21	SE 6	1	B3-N2		Not used in control, Roll (X ²) Error –UC
RP 22	SE 6	2	B3-N2	LOS Sensor (L)	Not used in control, Pitch (Y ^{B3}) Error – UC Not used in control, Yaw (Z ^{B3}) Error – UC
RP 23	SE 6	3	B3-N2	(LOS Along -Y ¹)	
RP 24	SE 6	4	B3-N2	(Negative Polar Axis)	Not used in control
RP 25	SE 6	5	B3-N2	see .los file	Not used in control
RP 26	SE 6	6	B3-N2		Not used in control
RP 27	SE 6	7	B3-N2		Not used in control
RP 28	SE 7	1	B4-N2		Not used in control, Roll (XB4) Error – LC
RP 29	SE 7	2	B4-N2	LOS Sensor (L)	Not used in control, Pitch (YB4) Error - LC
RP 30	SE 7	3	B4-N2	(LOS Along +Y ¹)	Not used in control, Yaw (ZB4) Error LC
RP 31	SE 7	4	B4-N2	(Positive Polar Axis)	Not used in control
RP 32	SE 7	5	B4-N2	see .los file	Not used in control
RP 33	SE 7	6	B4-N2	1	Not used in control
RP 34	SE 7	7	B4-N2		Not used in control

29 Decen	nder 2000			
		Tabl	e A.1.2 Actuator D	refinitions (Concept 1)
Global Actuator Input No.	TREETOPS Actuator Designation	Sensor Mount Loc.	Туре	DOF
UP 1 UP 2	AC 1 AC 2	B2-N2 B2-N2	Moment Actuator (MO)* Moment Actuator (MO)*	Pitch (Y ^{B2}) Ext. Torque – Overall System (Central Body) Yaw (Z ^{B2}) Ext. Torque – Overall System (Central Body) Roll (X ^{B2}) Ext. Torque – Overall System (Central Body)
UP 3 UP 4	AC 3	B2-N2 H2-A1	Moment Actuator (MO)* Motor Torque (T)** Reaction Jet (J)	Yaw (Z ^{BI}) Torque, equal and opposite, on Boom/Central Body -X ^{B2} Force at Central Body Transmitter
UP 5	AC 5	B2-N5	Reaction Jet (3) Radiation Pressure Disturbance	, , , , , ,

Notes:

- 1) Moment Actuator (MO) in TREETOPS is an External Moment applied to a Body (Reacts against Space) Used in Control
- ** 2) Motor Torque (T) in TREETOPS produces equal and opposite torques on the bodies adjacent to the hinge with the magnitude of the torque equal to the applied command level. A positive torque tends to increase the Euler angle associated with the mounting axis in a right hand sense.
 - 3) H2-A1 is hinge 2 axis 1

Table A.1.3: Interconnect Data and Significant Parameters for TREETOPS Continuous Matrix (CM) Controller (Concept 1)

	Interconnec	S	S No. C No.	S Out No.	Gain	Conti	nuous Ma in xdot	t Parameters in trix (CM) Control lin file = Ax + Bu = Cx + Du Subset of	Subset of
Inter- connect	Description	C C A	C No. A No.	C Out No. A In No.	N-m or N	A Matrix	B Matrix	C Matrix ω² 2ζω	D Matrix
IC 1	Pitch (Y ^{B2}) of Overall System	S C	1	1	4.41E13	0. 1.	0	.000025 .007	0
IC 2	Then (1) of Overall System	<u>C</u>	1 	1 1	1.0	-11.4	1		
IC 3	Yaw (ZB2) of Overall System	<u>S</u>	1	2 2	1.67E12	0. 1.	0	.000025 .007	0
IC 4	Yaw (Z) of Overall System	C	1 2	2	1.0	-11.4	1		
IC 5	Roll (X ^{B2}) of Overall System	S	2	3	4.31E13	0. 1.	0	.000025 .007	0
IC 6	Kon (X) or overall system	C A	1 3	3	1.0	-11.4	1		
IC 7	Yaw (Z ^{BI}) of Boom	<u>S</u>	3	1 4	6.7E8	0. 1.	0	1.E-6 1.4E-3	0
IC 8	Taw (Z.) OI BOOM	C	1 4	4	-1.0	-11.4	1		
IC 9	-X ^{B2} of Radiation Pres Disturb	S	3 5	3	7.0				

6.2852173E11 6.2852173E11

0 0 0

1 0 0 0

2 0 0 0

1.6168633E5

3 0 0 3188.8

4 0 0 -3188.8

42 BO

43 BO

44 BO 6.7057352E8

46 BO

47 BO

48 BO

50 BO

51 BO

52 BO

1 Mass (kg)

isc3_flex_sol.int (Concept 1) Summer Solstice

TREETOPS REV 10P2 4/10/00

SIM CONTROL

```
ISC MODEL, THIRD VERSION
      0 Title
1 SI
                                                               100000
       0 Simulation stop time
                                                               20
       0 Plot data interval
 3 ST
        0 Integration type (R,S,U, OR V)
                                                               R
                                                               . 1
       0 Step size (sec)
 5 SI
       O Sandia ODE solver absolute and relative error
 6 SI
       0 RK78 ODE solver absolute error and first step size
7 SI
       0 Linearization option (L,Z or N)
                                                               N
8 SI
                                                               N
       0 Restart option
                                (Y/N)
9 SI
       O Contact force computation option
                                                               Y
                                                (Y/N)
10 SI
        0 Constraint force computation option (Y/N)
                                                               N
11 SI
        0 Small angle speedup option (All, Bypass, First, Nth)
                                                               Α
12 SI
        0 Mass matrix speedup option (All, Bypass, First, Nth)
       0 Non-Linear speedup option (All, Bypass, First, Nth) A 0 Constraint speedup option (All, Bypass, First, Nth) A
14 SI
15 SI
       O Constraint stabilization option (Y/N)
16 SI
      0 Stabilization epsilon
17 SI
          GENGRAV
        0 Gravity, earth sphere/nonsphere/user (S/N/U)?
18 GG
        1 Input gravity constants: GME, ERAD, EMASS
19 GG
20 GG
       1 Spherical or Nonspherical (S/N)?
       1 Gravity Potential Harmonics J2,J3,J4
21 GG
                                                      (E/M)?
        0 English (ft-slug-s) or metric (m-kg-s)
22 GG
                                                               20 6 2020
        0 Day, Month, Year,
23 GG
        0 GMT @ sim time 0 (minutes past midnight,
                                                               360
24 GG
                                                               Y
        O Solar Pressure forces Y/N?
25 GG
        0 Input new data for aero model? (Y/N)
                                                               N
26 GG
       Solar flux F10 for aero model
27 GG
            Solar flux, 81 day average F10B
28 GG
       1
       1 Geomagnetic index, GEAP
29 GG
          BODY
                                                               1
       1 Body ID number
30 BO
                                                               F
        1 Type (Rigid, Flexible, NASTRAN)
31 BO
                                                               24
       1 Number of modes
32 BO
                                                               2
       1 Modal calculation option (0, 1 or 2)
33 BO
       1 Foreshortening option (Y/N)
34 BO
        1 Model reduction method (NO,MS,MC,CC,QM,CV)
35 BO
       1 NASTRAN data file FORTRAN unit number (40 - 60)
36 BO
       1 Number of augmented nodes (0 if none)
37 BO
        1 Damping matrix option (NS,CD,HL,SD)
38 BO
       1 Constant damping ratio
39 BO
       1 Low frequency, High frequency ratios
40 BO
       1 Mode ID number, damping ratio
41 BO
        1 Conversion factors: Length, Mass, Force
```

1 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1

1 Moments of inertia (kg-m2) Ixx,Iyy,Izz

45 BO 1 Products of inertia (kg-m2) Ixy, Ixz, Iyz

49 BO 1 Node ID, Node coord. (meters) x,y,z

1 Number of Nodes 1 Node ID, Node coord. (meters) x,y,z

1 Node ID, Node coord. (meters) x,y,z 1 Node ID, Node coord. (meters) x,y,z

1 Node ID, Node structual joint ID

```
2 Body ID number
 53 BO
 54 BO 2 Type (Rigid, Flexible, NASTRAN)
         2 Number of modes
2 Modal calculation option (0, 1 or 2)
 55 BO
 56 BO
         2 Foreshortening option (Y/N)
 57 BO
         2 Model reduction method (NO,MS,MC,CC,QM,CV)
 58 BO
          2 NASTRAN data file FORTRAN unit number (40 - 60)
 59 BO
         2 Number of augmented nodes (0 if none)
 60 BO
         2 Damping matrix option (NS,CD,HL,SD)
 61 BO
         2 Constant damping ratio
 62 BO
          2 Low frequency, High frequency ratios
  63 BO
         2 Mode ID number, damping ratio
 64 BO
         2 Conversion factors: Length, Mass, Force
         2 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
2 Moments of inertia (kg-m2) Ixx, Iyy, Izz .8543E12 1.5601E12
 66 BO
  67 BO
1.3822E12
                                                                     0 0 0
  68 BO 2 Products of inertia (kg-m2) Ixy,Ixz,Iyz
 69 BO 2 Mass (kg)
70 BO 2 Number of Nodes
                                                                      12666300
                                                                      1 298.323 0 0
  71 BO 2 Node ID, Node coord. (meters) x,y,z
 72 BO 2 Node ID, Node coord. (meters) x,y,z
                                                                     2 0 0 0
          2 Node ID, Node coord. (meters) x,y,z
                                                                     3 0 0 300
  73 BO
                                                                      4 0 0 -300
  74 BO 2 Node ID, Node coord. (meters) x,y,z
  75 BO 2 Node ID, Node coord. (meters) x,y,z
                                                                      5 500 0 0
  76 BO 2 Node ID, Node structual joint ID
                                                                       3
         3 Body ID number
  77 BO
  78 BO 3 Type (Rigid, Flexible, NASTRAN)
                                                                       R
          3 Number of modes
  79 BO
          3 Modal calculation option (0, 1 or 2)
  80 BO
         3 Foreshortening option (Y/N)
  81 BO
         3 Model reduction method (NO,MS,MC,CC,QM,CV)
  82 BO
          3 NASTRAN data file FORTRAN unit number (40 - 60)
  83 BO
         3 Number of augmented nodes (0 if none)
  84 BO
  85 BO 3 Damping matrix option (NS,CD,HL,SD)
         3 Constant damping ratio
3 Low frequency, High frequency ratios
  86 BO
  87 BO
  88 BO
          3 Mode ID number, damping ratio
         3 Conversion factors: Length, Mass, Force
  89 BO
          3 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
  90 BO
         3 Moments of inertia (kg-m2) Ixx, Iyy, Izz 1.7E12 1.7E12 3.4E12
  91 BO
  92 BO 3 Products of inertia (kg-m2) Ixy,Ixz,Iyz
                                                                      0 0 0
                                                                     2046600
         3 Mass (kg)
3 Number of Nodes
  93 BO
  94 BO
                                                                      1 0 0 0
         3 Node ID, Node coord. (meters) x,y,z
  95 BO
                                                                      2 0 0 0
         3 Node ID, Node coord. (meters) x,y,z
3 Node ID, Node structual joint ID
  96 BO
  97 BO
                                                                       4
  98 BO 4 Body ID number
  99 BO 4 Type (Kryza,
100 BO 4 Number of modes
          4 Type (Rigid, Flexible, NASTRAN)
 100 BO
 101 BO 4 Modal calculation option (0, 1 or 2)
 102 BO 4 Foreshortening option (Y/N)
103 BO 4 Model reduction method (NO,MS,MC,CC,QM,CV)
104 BO 4 NASTRAN data file FORTRAN unit number (40 - 60)
 105 BO 4 Number of augmented nodes (0 if none)
         4 Damping matrix option (NS,CD,HL,SD)
4 Constant damping ratio
 106 BO
 107 BO
         4 Low frequency, High frequency ratios
 108 BO
         4 Mode ID number, damping ratio
 109 BO
          4 Conversion factors: Length, Mass, Force
 110 BO
         4 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
 111 BO
 112 BO 4 Moments of inertia (kg-m2) Ixx,Iyy,Izz 1.7E12 1.7E12 3.4E12 113 BO 4 Products of inertia (kg-m2) Ixy,Ixz,Iyz 0 0 0
         4 Products of inertia (kg-m2) Ixy,Ixz,Iyz
4 Mass (kg)
                                                                      2046600
 114 BO
 115 BO 4 Number of Nodes
 116 BO 4 Node ID, Node coord. (meters) x,y,z
117 BO 4 Node ID, Node coord. (meters) x,y,z
118 BO 4 Node ID, Node structual joint ID
                                                                      1 0 0 0
                                                                       2 0 0 0
```

Bd Systems® TCD20000222A 29 December 2000 HINGE

119	HI	1	Hinge ID number	1
120			Inboard body ID, Outboard body ID	0 1
121	ΗI	1	"p" node ID, "q" node ID	0 2
122	ΗI	1	Number of rotation DOFs, Rotation option (F or G)	3 F
123	ΗI	1	L1 unit vector in inboard body coord. x,y,z	1 0 0
124	ΗI	1	L1 unit vector in outboard body coord. x,y,z	1 0 0
125	ΗI	1	L2 unit vector in inboard body coord. x,y,z	
126	ΗI	1	L2 unit vector in outboard body coord. x,y,z	0 0 1
127	ΗI	1	L3 unit vector in inboard body coord. x,y,z	0 0 1
128	ΗI	1	L3 unit vector in outboard body coord. x,y,z	0 0 1
129	ΗI	1	Initial rotation angles (deg)	-90 0 90
130	ΗI		Initial rotation rates (deg/sec)	0 0 0
131	ΗI		Rotation stiffness (newton-meters/rad)	0 0 0
132		1	Rotation damping (newton-meters/rad/sec)	0 0 0
133			Null torque angles (deg)	
134			Number of translation DOFs	3 1 0 0
135			First translation unit vector g1	0 1 0
136			Second translation unit vector g2	0 0 1
137			Third translation unit vector g3	0 0 42163421
138			Initial translation (meters)	3074.681 0 0
139		1	Initial translation velocity (meters/sec)	0 0 0
140		1	Translation stiffness (newtons/meters)	0 0 0
141			Translation damping (newtons/meter/sec)	0 0 0
142	H1	1	Null force translations	0 0 0
1.40		2	Ningo ID number	2
143			Hinge ID number Inboard body ID, Outboard body ID	1 2
144		2	"p" node ID, "q" node ID	2 2
145		2		1
146			L1 unit vector in inboard body coord. x,y,z	0 0 1
147		2	L1 unit vector in outboard body coord. x,y,z	0 0 1
148		2	L2 unit vector in inboard body coord. x,y,z	0 0 1
149		2	L2 unit vector in outboard body coord. x,y,z	
150		2	L3 unit vector in inboard body coord. x,y,z	1 0 0
151		2	L3 unit vector in outboard body coord. x,y,z	1 0 0
152		2	Initial rotation angles (deg)	0 0 0
153			Initial rotation rates (deg/sec)	0.00417807
154			Rotation stiffness (newton-meters/rad)	0
155		2	Rotation damping (newton-meters/rad/sec)	0
156		2	Null torque angles (deg)	0
157 158			Number of translation DOFs	0
159		_	First translation unit vector g1	1 0 0
			Second translation unit vector g2	0 1 0
160 161			Third translation unit vector g3	0 0 1
162			Initial translation (meters)	0 0 0
163			Initial translation velocity (meters/sec)	
164		2	Translation stiffness (newtons/meters)	
165		2	Translation damping (newtons/meter/sec)	
166			Null force translations	
100	***	_		
167	ΗĪ	3	Hinge ID number	3
168		3	Inboard body ID, Outboard body ID	1 3
169		3	"p" node ID, "q" node ID	3 2
170		3		0
171		3	L1 unit vector in inboard body coord. x,y,z	0 0 1
172		3	L1 unit vector in outboard body coord. x,y,z	0 0 1
173		3	L2 unit vector in inboard body coord. x,y,z	
174	ΗI	3	L2 unit vector in outboard body coord. x,y,z	
175	ΗI	3	L3 unit vector in inboard body coord. x,y,z	0 1 0
176	ΗI	3	L3 unit vector in outboard body coord. x,y,z	0 1 0
177	ΗI	3	Initial rotation angles (deg)	90 0 -123.25
178	ΗI	3	Initial rotation rates (deg/sec)	
179	ΗI	3	Rotation stiffness (newton-meters/rad)	
180	ΗI		Rotation damping (newton-meters/rad/sec)	
181	ΗI		Null torque angles (deg)	0
182		3	Number of translation DOFs	0
183		3	First translation unit vector gl	1 0 0
184	ΗI	3	Second translation unit vector g2	0 1 0

```
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                                                                                                NAS8-00151
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                                                                            0 0 1
 185 HI 3 Third translation unit vector g3
                                                                            0 0 0
          3 Initial translation (meters)
 187 HI 3 Initial translation velocity (meters/sec)
 188 HI 3 Translation stiffness (newtons/meters)
189 HI 3 Translation damping (newtons/meter/sec)
 190 HI 3 Null force translations
           4 Hinge ID number
                                                                            1 4
 192 HI 4 Inboard body ID, Outboard body ID
 193 HI 4 "p" node ID, "q" node ID
                                                                            4 2
194 HI 4 Number of rotation DOFs
195 HI 4 L1 unit vector in inboard body coord. x,y,z
196 HI 4 L1 unit vector in outboard body coord. x,y,z
                                                                            0 0 1
                                                                            0 0 1
 197 HI 4 L2 unit vector in inboard body coord. x,y,z
          4 L2 unit vector in outboard body coord. x,y,z
4 L3 unit vector in inboard body coord. x,y,z
 198 HI
                                                                            0 1 0
 199 HI
                                                                            0 1 0
          4 L3 unit vector in outboard body coord. x,y,z
 200 HI
201 HI 4 Initial rotation angles (deg)
202 HI 4 Initial rotation rates (deg/sec)
203 HI 4 Rotation stiffness (newton-meters/rad)
                                                                            90 0 -33.25
 204 HI 4 Rotation damping (newton-meters/rad/sec)
 205 HI 4 Null torque angles (deg)
206 HI 4 Number of translation DOFs
                                                                            0
                                                                            1 0 0
 207 HI 4 First translation unit vector g1
                                                                            0 1 0
 208 HI 4 Second translation unit vector g2
 209 HI 4 Third translation unit vector
210 HI 4 Initial translation (meters)
                                                                            0 0 1
                                                     g3
                                                                            0 0 0
 211 HI 4 Initial translation velocity (meters/sec)
 212 HI 4 Translation stiffness (newtons/meters)
213 HI 4 Translation damping (newtons/meter/sec)
214 HI 4 Null force translations
              SENSOR
 215 SE 1 Sensor ID number
 216 SE 1 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ET 217 SE 1 Mounting point body ID, Mounting point node ID 2 2
 218 SE 1 Second mounting point body ID, Second node ID
          1 Input axis unit vector (IA) x,y,z
 219 SE
           1 Mounting point Hinge index, Axis index
 220 SE
                                                                            0 0 -1
          1 First focal plane unit vector (Fp1) x,y,z
 221 SE
 222 SE 1 Second focal plane unit vector (Fp2) x,y,z
                                                                            0 1 0
          1 Sun/Star unit vector (Us) x,y,z
1 Velocity Aberration Option (Y/N)
 223 SE
 224 SE
          1 Euler Angle Sequence (1-6)
 225 SE
          1 CMG ID number and Gimbal number
1 Earth pt (rad,lat,lon,rotation [m/e, d, d, d/s]) 6378000 0 0 4.178074D-3
 226 SE
 227 SE
          2 Sensor ID number
 228 SE
            2 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST
 229 SE
 230 SE 2 Mounting point body ID, Mounting point node ID
 231 SE 2 Second mounting point body ID, Second node ID
 232 SE 2 Input axis unit vector (IA) x,y,z
233 SE 2 Mounting point Hinge index, Axis index
                                                                            0 -1 0
 234 SE 2 First focal plane unit vector (Fp1) x,y,z
          2 Second focal plane unit vector (Fp2) x,y,z
                                                                            1 0 0
 235 SE
                                                                            0 1 0
            2 Sun/Star unit vector (Us) x,y,z
 236 SE
          2 Velocity Aberration Option (Y/N)
                                                                            N
 237 SE
          2 Euler Angle Sequence (1-6)
 238 SE
          2 CMG ID number and Gimbal number
2 Earth pt (rad,lat,lon,rotation [m/e, d, d, d/s])
 239 SE
 240 SE
           3 Sensor ID number
 241 SE
            3 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST
 242 SE
 243 SE 3 Mounting point body ID, Mounting point node ID
 244 SE 3 Second mounting point body ID, Second node ID
          3 Input axis unit vector (IA) x,y,z
3 Mounting point Hinge index, Axis index
 245 SE
 246 SE
                                                                            -1 0 0
 247 SE 3 First focal plane unit vector (Fp1) x,y,z
 248 SE 3 Second focal plane unit vector (Fp2) x,y,z
                                                                            0 0 1
```

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				0 0	0	
249		3	Sun/Star unit vector (Us) x,y,z	N	v	
250		3	Velocity Aberration Option (Y/N)	14		
251	SE	3	Euler Angle Sequence (1-6)			
252	SE	3	CMG ID number and Gimbal number			
253	SE	3	Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])			
254	SE	4	Sensor ID number	4		
255	SE	4	Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET)	A3		
256	SE	4	Mounting point body ID, Mounting point node ID	1 2		
257	SE	4	Second mounting point body ID, Second node ID			
258	SE	4	Input axis unit vector (IA) x,y,z			
259	SE	4	Mounting point Hinge index, Axis index			
260		4	First focal plane unit vector (Fp1) x,y,z			
261		4	Second focal plane unit vector (Fp2) x,y,z			
262		4	Sun/Star unit vector (Us) x,y,z			
263		4	Velocity Aberration Option (Y/N)			
264		4	Euler Angle Sequence (1-6)			
265		4	CMG ID number and Gimbal number			
266		1	Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])			
200	JL	-	daten pe (1997-1997-1997)			
267	CF	5	Sensor ID number	5		
		5	Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET)	LV		
268		2	Mounting point body ID, Mounting point node ID	1 2		
269 270		5	Second mounting point body ID, Second node ID			
		כ	Input axis unit vector (IA) x,y,z			
271		2	Mounting point Hinge index, Axis index			
272		2	First focal plane unit vector (Fp1) x,y,z			
273		5	First rocal plane unit vector (Fp1) X,Y,Z			
274		5	Second focal plane unit vector (Fp2) x,y,z			
275		5	Sun/Star unit vector (Us) x,y,z			
276			Velocity Aberration Option (Y/N)			
277		5	Euler Angle Sequence (1-6)			
278		5	CMG ID number and Gimbal number			
279	SE	5	Earth pt $(rad, lat, lon, rotation [m/e, d, d, d/s])$			
				6		
280		6	Sensor ID number			
281	SE	6	Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV	ъ ъ		
282	SE	6	Mounting point body ID, Mounting point node ID	3 2		
283	SE	6	Second mounting point body ID, Second node ID	1 0	0	
284	SE	6	Input axis unit vector (IA) x,y,z	1 0	U	
285	SE	6	Mounting point Hinge index, Axis index			
286	SE	6	First focal plane unit vector (Fp1) x,y,z			
287	SE	6	Second focal plane unit vector (Fp2) x,y,z			
288	SE	6	Sun/Star unit vector (Us) x,y,z			
289	SE	6	Velocity Aberration Option (Y/N)			
290	SE	6	Euler Angle Sequence (1-6)			
291	SE	6	CMG ID number and Gimbal number			
292	SE	6	Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])			
293	SE	7	Sensor ID number	7		
294		7	TVD (G.R.AN, V.P.AC, T.I., SU, ST.L., IM, P3, V3, CR, CT, ET, LV	L		
295		7	Mounting point body ID, Mounting point node ID	4 2		
296		7	Second mounting point body ID, Second node ID			
297		7	Input axis unit vector (IA) x,y,z	1 0	0	
298		7	Mounting point Hinge index, Axis index			
299		7	First focal plane unit vector (Fp1) x,y,z			
300		7	Second focal plane unit vector (Fp2) x,y,z			
301		7	Sun/Star unit vector (Us) x,y,z			
302		7	Velocity Aberration Option (Y/N)			
302		7	Euler Angle Sequence (1-6)			
	SE	7	CMG ID number and Gimbal number			
	SE	7	Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])			
303	36	,	bartin pe (raa/rae/rae/rae/			
			ACTR			
306	AC	1	Actuator ID number	1		
	AC	1	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7)	MO		
	AC	1	Actuator location; Node or Hinge (N or H)			
	AC	1	Mounting point body ID number, node ID number	2 2		
	AC	1	Second mounting point body ID, second node ID			
	AC	1	Output axis unit vector x,y,z	0 1	0	
	_					

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312 AC 1 Mounting point Hinge index, Axis index
313 AC 1 Rotor spin axis unit vector x,y,z
314 AC 1 Initial rotor momentum, H

312		1	Rotor spin axis unit vector x,y,z	
313		1	Initial rotor momentum, H	
314		1	Outer gimbal- angle(deg), inertia, friction(D, S, B, N)	
315		1	Outer gimbal axis unit vector x,y,z	
316		1	Out gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k)	
317		1	Inner gimbal- angle (deg), inertia, friction (D, S, B, N)	
318		1	Inner gimbal axis unit vector x,y,z	
319		1	In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)	
320		1	Initial length and rate, y(to) and ydot(to)	
321		1	Constants; K1 or wo, n or zeta, Kg, Jm	
322		1	Non-linearities; TLim, Tco, Dz	
323	AC	1	NON-Illieditcles, Thim, 100, 52	
324	ΔC	2	Actuator ID number	2
325		2	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7)	MO
326		2	Actuator location; Node or Hinge (N or H)	
327		2	Mounting point body ID number, node ID number	2 2
328		2	Second mounting point body ID, second node ID	
329		2	Output axis unit vector x,y,z	0 0 1
330		2	Mounting point Hinge index, Axis index	
331		2	Rotor spin axis unit vector x,y,z	
332		2	Initial rotor momentum, H	
333		2	Outer gimbal- angle(deg), inertia, friction(D, S, B, N)	
334		2	Outer gimbal axis unit vector x,y,z	
335		2	Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k)	
336		2	Inner gimbal- angle(deg), inertia, friction(D, S, B, N)	
337		2	Inner gimbal axis unit vector x,y,z	
338		2	In gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k)	
339	AC	2	Initial length and rate, y(to) and ydot(to)	
340		2	Constants; K1 or wo, n or zeta, Kg, Jm	
341		2	Non-linearities; TLim, Tco, Dz	
				2
342	AC	3	Actuator ID number	3
343	AC	3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7)	MO
344	AC	3	Actuator location; Node or Hinge (N or H)	2 2
345	AC	3	Mounting point body ID number, node ID number	2 2
346	AC	3	Second mounting point body ID, second node ID	1 0 0
347	AC	3	Output axis unit vector x,y,z	1 0 0
348		3	Mounting point Hinge index, Axis index	
349		3	Rotor spin axis unit vector x,y,z	
350		3	Initial rotor momentum, H	
	AC	3	Outer gimbal- angle(deg), inertia, friction(D, S, B, N)	
	AC	3	Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)	
	AC	3	Inner gimbal- angle(deg), inertia, friction(D, S, B, N)	
	AC	3	Inner gimbal axis unit vector x,y,z	
	AC	3	In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)	
	AC	2	Initial length and rate, y(to) and ydot(to)	
	AC	2	Constants; K1 or wo, n or zeta, Kg, Jm	
359	AC	3	Non-linearities; TLim, Tco, Dz	
555	110	,	Hon Image to the control of the cont	
360	AC		Actuator ID number	4
	AC	4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7)	T
362	AC	4	Actuator location: Node or Hinge (N or H)	
363	AC	4	Mounting point body ID number, node ID number	
364	AC	4	Second mounting point body ID, second node ID	
365	AC	4	Output axis unit vector x,y,z	
366	AC	4	Mounting point Hinge index, Axis index	2 1
367	AC	4	Rotor spin axis unit vector x,y,z	
368	AC	4	Initial rotor momentum, H	
369	AC	4	Outer gimbal- angle(deg), inertia, friction(D,S,B,N)	
	AC	4	Outer gimbal axis unit vector x,y,z	
	AC	4	Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k)	
	AC	4	<pre>Inner gimbal- angle(deg),inertia,friction(D,S,B,N)</pre>	
	AC	4	Inner gimbal axis unit vector x,y,z	
	AC	4	In gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k)	
	AC	4	Initial length and rate, y(to) and ydot(to)	
	AC	4	Constants; K1 or wo, n or zeta, Kg, Jm	
377	AC	4	Non-linearities; TLim, Tco, Dz	
379	AC	5	Actuator ID number	5
5,0	110			

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Bd S ₂			2.4	
1CD. 29 De				
379		5	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US)	J
380		5	Actuator location; Node or Hinge (N or H)	0 5
381	AC	5	Mounting point body ID number, node ID number	2 5
382		5	Second mounting point body ID, second node ID	-1 0 0
383		5	Output axis unit vector x,y,z Mounting point Hinge index, Axis index	100
384 385		5	Rotor spin axis unit vector x,y,z	
386		5	Initial rotor momentum, H	
387		5	Outer gimbal- angle(deg), inertia, friction(D, S, B, N)	
388	AC	5	Outer gimbal axis unit vector x,y,z	
389		5	Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg),inertia,friction(D,S,B,N)	
390		5	Inner gimbal axis unit vector x,y,z	
391 392		5	In gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k)	
393		5	Initial length and rate, y(to) and ydot(to)	
394	AC	5	Constants; K1 or wo, n or zeta, Kg, Jm	
395	AC	5	Non-linearities; TLim, Tco, Dz	
			CONTROLLER	
206	со	1	Controller ID number	1
-	CO		Controller type (CB,CM,DB,DM,UC,UD)	CM
	CO	1	Sample time (sec)	
	CO		Number of inputs, Number of outputs	4 4
	CO	1	Number of states Output No., Input type (I,S,T), Input ID, Gain	
401	CO	1	output No., input type (1,5,1), imput 15, data	
			INTERCONNECT	
402	IN	1	Interconnect ID number	1
	IN	1	Source type(S.C. or F), Source ID, Source row #	S 1 1
404	IN	1	Destination type(A or C), Dest ID, Dest row #	C 1 1
405	IN	1	Gain	4.41E13
406	IN	2	Interconnect ID number	2
	IN	2	Source type(S,C, or F),Source ID,Source row #	C 1 1
	IN		Destination type(A or C), Dest ID, Dest row #	A 1 1 1
409	IN	2	Gain	1
410	IN	3	Interconnect ID number	3
	IN	3	Source type(S,C, or F), Source ID, Source row #	S 1 2 C 1 2
	IN		Destination type(A or C), Dest ID, Dest row # Gain	1.67E12
413	IN	3	GdIII	
414	IN	4	Interconnect ID number	4
	IN	4	Source type(S,C, or F), Source ID, Source row #	C 1 2 A 2 1
	IN		Destination type(A or C), Dest ID, Dest row # Gain	1
41/	714	4	Gain	
418	IN	5	Interconnect ID number	5 S 2 1
	IN	5	Source type(S,C, or F), Source ID, Source row #	C 1 3
	IN		Destination type(A or C),Dest ID,Dest row # Gain	4.31E13
421	111			_
	IN	6	Interconnect ID number	6 C 1 3
	IN	6	Source type(S,C, or F),Source ID,Source row # Destination type(A or C),Dest ID,Dest row #	A 3 1
	IN		Gain	1
				7
	IN	7	Interconnect ID number	7 S 3 1
	IN	7	Source type(S,C, or F),Source ID,Source row # Destination type(A or C),Dest ID,Dest row #	C 1 4
	IN IN		Gain	6.7E8
		_	To be a second of the second o	8
	IN	8	<pre>Interconnect ID number Source type(S,C, or F),Source ID,Source row #</pre>	C 1 4
	IN IN	8	Destination type(A or C), Dest ID, Dest row #	A 4 1
	IN		Gain	1

Contract No. NAS8-00151 Final Report

isc3_flex_sol.lin (Concept 1) Summer Solstice

```
* Controller for integrated symmetrical concentrator
system CONT1 8,4,4,0,0,0.0
*A
0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0
-1 -1.4 0 0 0 0 0 0
0 0 0 1 0 0 0 0
0 0 -1 -1.4 0 0 0 0
0 0 0 0 0 1 0 0
0 0 0 0 -1 -1.4 0 0
0 0 0 0 0 0 0 1
0 \ 0 \ 0 \ 0 \ 0 \ -1 \ -1.4
*B
0 0 0 0
1 0 0 0
0 0 0 0
0 1 0 0
0 0 0 0
0 0 1 0
0 0 0 0
0 0 0 1
*C
.000025 .007 0 0 0 0 0 0
0 0 .000025 .007 0 0 0 0
0 0 0 0 .000025 .007 0 0
0 0 0 0 0 0 1e-2 1.4e-1
*D
0 0 0 0
0 0 0 0
0 0 0 0
0 0 0 0
*H
*M
```

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29 December 2000

los.dat (Concept 1) Summer Solstice

```
Defaults to sun as a target for zero input vector
                                                                                                                                                                                                 Defaults to sun as a target for zero input vector
                                                                                                                                                                                                                         Target star along positive polar axis
                                                  Target star along negative polar axis
                                                                                                                                                                         ! Sensor number of 2nd FGS (clamshell) sensor
number of 1st FGS (clamshell) sensor
                                                                                                                                                                                                                                                                        Focal plane vector 2 Focal plane vector 3
                                                                                              ! Focal plane vector 2 ! Focal plane vector 3
                                                                                                                                                                                                                                                      Focal plane vector 1
                                                                          Focal plane vector 1
    : Sensor
                      0.d0,0.d0,0.d0,
0.d0, -1.d0,0.d0,
                                                                          0.d0,-1.d0,0.d0,
                                                                                                                                                                                                                                                    0.d0,-1.d0,0.d0,
                                                                                                                                                                                                                         0.d0, 1.d0,0.d0,
                                                                                                                                                                                                                                                                                                      -1.d0,0.d0,0.d0
                                                                                                1.d0,0.d0,0.d0,
1.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                          1.d0,0.d0,0.d0,
                                                                                                                                                                                                 0.d0,0.d0,0.d0,
```

solar pressure.dat (Concept 1) Summer Solstice

```
! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              ! body, node, area, reflectivity factor, outward normal, centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  ! body, node, area, reflectivity factor, outward normal, centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                            ' body, node, area, reflectivity factor,outward normal,centroid
' body, node, area, reflectivity factor,outward normal,centroid
' body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                 ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                             ! body, node, area, reflectivity factor, outward normal, centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 normal, centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              ! body, node, area, reflectivity factor, outward normal, centroid
                                                            ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                            ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                            ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                            ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      area, reflectivity factor, outward normal, centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  body, node, area, reflectivity factor, outward normal, centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   body, node, area, reflectivity factor, outward normal, centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       body, node, area, reflectivity factor,outward normal,centroid body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 ! body, node, area, reflectivity factor, outward
22, 'm', inumber of panels, units English or Metric ***Updated 11/15/00*** 1,2,638000.d0,0.5d0,1.d0,0.d0,0.d0,0.d0,0.d0, ibody, node, area, reflectively, 638000.d0,0.5d0,0.d0,1.d0,0.d0,0.d0,0.d0,0.d0, ibody, node, area, reflectively
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          body, node,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      2,4,785000.d0,0.0d0, -0.1736d0,-1.d0,0.9848d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     2,3,785000.d0,0.0d0, 0.1736d0,0.d0,0.9848d0,0.d0,0.d0,0.d0,
2,3,785000.d0,0.0d0, -0.1736d0,1.d0,-0.9848d0,0.d0,0.d0,0.d0,
2,4,785000.d0,0.0d0, 0.1736d0,0.d0,-0.9848d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                                                                                                                     1,3,3190000.d0,0.5d0,-1.d0,0.d0,0.d0,0.d0,0.d0,-7.972d2,1,3,3190000.d0,0.5d0,0.5d0,-1.d0,0.d0,0.d0,0.d0,-7.972d2,
                                                                                                                                                                                                                                                        1,3,319000.d0,0.5d0,1.d0,0.d0,0.d0,0.d0,0.d0,-7.972d2,1,3,319000.d0,0.5d0,0.d0,1.d0,0.d0,0.d0,0.d0,0.d0,-7.972d2,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                     1,4,319000.d0,0.5d0,1.d0,0.d0,0.d0,0.d0,0.d0,7.972d2,1,4,319000.d0,0.5d0,0.d0,1.d0,0.d0,0.d0,0.d0,7.972d2,1,4,319000.d0,0.5d0,-1.d0,0.d0,0.d0,0.d0,0.d0,7.972d2,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             1,4,319000.d0,0.5d0,0.d0,-1.d0,0.d0,0.d0,0.d0,7.972d2,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          2,5,196000.d0,0.0d0, 1.d0,0.d0,0.d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          2,5,196000.d0,0.0d0,-1.d0,0.d0,0.d0,0.d0,0.d0,0.d0,
                                                                                                                                                                    1,2,638000.d0,0.5d0,-1.d0,0.d0,0.d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                        1,2,638000.d0,0.5d0,0.d0,-1.d0,0.d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       3,2,1.04d7,1.0d0,0.d0,0.d0,1.d0,0.d0,0.d0,0.d0,
```

isc3_flex_sol.flx (Concept 1) Summer Solstice (An excerpt)

```
flag, revision number
XXXXXX
  body id
          1
   modes, nodes, modal options
                                                                                                  0
                                                                         0
                                                                                      0
                                                            0
                                                0
                       4
                                   0
         24
                                                                                     0
                                                                                                  0
                                                0
                                                            0
                                                                         0
                       0
                                    0
           n
                                                                                                  O
                                                                                      0
                                                            0
                                                0
           0
                       0
                                   0
                                                                         0
                                                                                                  0
                                                0
                                                            0
                       0
                                   0
           0
                                           2
   phi_t for node #
   .31310941E-02 -.16357954E-03 .19158607E-08 .68659216E-04 .31346273E-02
 .14949358E-08 -.33409338E-09 -.17910070E-08 -.62130721E-04 .10048928E-08 .74260327E-10 -.81693812E-09 .66744219E-10 -.57300403E-09 .56292416E-10 -.31109642E-09 .51999889E-08 .41569313E-10 .36697769E-02 .69502051E-03 .85567197E-10 -.10557893E-02 .35826871E-02 .65924560E-10 .61553749E-10
   .11085623E-08 -.67301328E-05 .49549244E-10 -.49437998E-08 -.60865848E-11
 .10484816E-08 .39239830E-10 -.17858973E-09 .46440350E-10 .23145265E-09 .76239104E-11 -.98486197E-09 -.52382674E-09 .30708566E-12 .12143532E-10 -.10722701E-09 .94529479E-03 .17735129E-08 .15323995E-09 .13868812E-12
 -.13390485E-02 -.55272105E-04 -.82202021E-12 .55317399E-04 -.13390483E-02
   .27552836E-11 .29149021E-10 -.27567962E-12 -.44865972E-10 .48584658E-11
   .10595799E-10 -.31919479E-08 -.19937738E-10 .14255509E-09 -.23770452E-02
 -.45933446E-03 -.19673179E-04 .63985161E-12 -.19675549E-04 .45933391E-03
 -.74265281E-12 -.34874105E-11 -.12587102E-11 .59687765E-09 -.12099360E-11
  -.69004494E-11 .19524343E-08
   phi_t prime for node #
   .17177767E-11 -.22808543E-11 -.45683561E-10 .19817016E-10 .56718933E-12
 .31514104E-09 .17463000E-11 -.27057756E-13 -.60467460E-12 .11400599E-06 -.42543750E-05 -.11919737E-10 .42546793E-05 .10153760E-06 -.34352434E-10 .41859459E-11 -.37080794E-11 .59234151E-04 .45504345E-11 -.70844966E-12
   .15588470E-10 .13593377E-10 .68741697E-12 .87795145E-10 -.28497036E-11
   .31909564E-13 -.69421743E-15 .38765922E-11 -.41335440E-11 -.44983453E-04 .22473012E-05 -.13022411E-04 .41075666E-11 -.13101519E-04 -.17274113E-05
  -.98017672E-11 -.14778531E-12 -.42275125E-13 -.96071643E-06 -.25440820E-11
   .54200130E-11 .41425181E-12 -.51084189E-13 .98880082E-15 .14899414E-06
  -.49351318E-14 .15066380E-14 -.42969795E-10 -.54223125E-14 .27635772E-15 
-.79851673E-11 .23444071E-06 -.40722409E-05 -.13017710E-13 .40722809E-05
   -.61449314E-07 -.27684414E-12
                                          3
   phi_t for node #
  -.42404714E-02 .49480955E-03 .19835813E-08 -.36612814E-03 -.42534660E-02
   .96750031E-09 .42209027E-09 .30963712E-08 .40516924E-04 .38549281E-02
  -.52714285E-03 -.87737477E-09 .53843743E-03 .38533672E-02 -.10363838E-09 .38623427E-08 -.71743451E-08 .24131659E-03 .31427071E-02 -.10270931E-03 .1581259E-09 -.20969267E-03 .31373775E-02 .44642715E-09 .28790083E-09
   .88009461E-09 .18408168E-03 -.17813513E-08 -.27431844E-08 .15957166E-04
  -.19242852E-02 .34087019E-03 -.22330623E-09 .41716037E-03 .19091971E-02 

-.71605887E-10 .95016675E-09 -.81490514E-09 .32861442E-02 -.18116747E-08 

.55541036E-09 .79551900E-03 -.41608643E-08 -.26069981E-09 .94036451E-02
  .21682867E-02 -.12127210E-02 .85710915E-08 .12126479E-02 .21683282E-02 -.39141685E-08 .18971552E-02 -.12009168E-02 .43705940E-08 .12012029E-02
    .18969745E-02 .16937062E-07 -.67726532E-08 -.66549206E-08 .11440634E-01 .49982895E-02 -.24804966E-02 .39527267E-09 -.24804686E-02 -.49983050E-02
  -.34622476E-08 -.50056020E-02 .25440974E-02 -.23331468E-08 -.25435047E-02
  -.50059046E-02 -.85708461E-08
   phi_t prime for node #
  -.50525028E-06 -.31564387E-05 -.80521842E-10 .31702786E-05 -.40940183E-06
   .57389171E-09 -.26678138E-11 .65900274E-12 -.58046889E-04 .10244708E-05 .47674564E-05 .15531760E-10 -.47644389E-05 .10384376E-05 .44257276E-10 .11200572E-10 .49389619E-11 -.61429724E-04 .68382965E-06 .54576833E-05
  -.20073106E-10 -.54985919E-05 .13880871E-06 -.11950858E-09 -.12906028E-11 .35486701E-12 -.77274292E-04 .61171041E-11 -.56114520E-11 -.65377923E-04
   -.17172111E-05 -.54788611E-05 .24079039E-11 -.54062017E-05 .19338345E-05
  .41797610E-11 .67570000E-11 .20000043E-10 .51675836E-06 -.99163146E-11 
-.24536147E-10 .16113741E-05 -.24387637E-10 -.45291231E-10 .14474359E-04 
.40550997E-04 .55846277E-04 -.22605263E-10 -.55847708E-04 .40549096E-04 
-.12064872E-11 .40806300E-04 .51925447E-04 -.22326921E-10 -.51919351E-04
```

```
.40814113E-04 .35521932E-10 .15828591E-09 -.16771401E-09 .21209458E-04
.16987298E-03 .27619447E-03 .11975439E-09 .27619558E-03 -.16987148E-03 -.57982074E-10 -.17376694E-03 -.27781790E-03 -.11765510E-09 .27783862E-03
-.17373409E-03 -.70075300E-10
 phi_t for node #
-.42404802E-02 .49480360E-03 .18585028E-08 -.36612933E-03 -.42535396E-02
  .21036956E-08 .39723035E-09 -.14786269E-09 .40516905E-04 -.38549306E-02
  .52714303E-03 -.77214743E-09 -.53843745E-03 -.38533660E-02 .20798890E-09
-.73886299E-08 -.15978809E-07 -.24131650E-03 .31427093E-02 -.10270436E-03 .13801450E-10 -.20968938E-03 .31373931E-02 -.39914612E-09 .41931685E-11 .99616139E-10 .18408168E-03 .35438059E-09 -.17390277E-08 -.15957178E-04
  .19242857E-02 -.34087031E-03 -.23866856E-09 -.41716036E-03 -.19091972E-02
-.19395891E-10 .94356214E-09 -.84924469E-09 -.32861442E-02 .18078300E-08
-.56604075E-09 .79551900E-03 -.41738415E-08 -.28114281E-09 -.94036451E-02
   .21682868E-02 -.12127209E-02 -.85410786E-08 .12126480E-02 .21683284E-02
.38256346E-08 -.18971552E-02 .12009169E-02 .43704936E-08 -.12012030E-02 
-.18969746E-02 .17005110E-07 .67789071E-08 .66775796E-08 .11440634E-01 
.49982897E-02 -.24804968E-02 -.39492666E-09 -.24804688E-02 -.49983053E-02
  .34827434E-08 .50056020E-02 -.25440973E-02 -.23324836E-08 .25435049E-02
   .50059050E-02 -.85841247E-08
                                                                4
  phi_t prime for node #
  .50524725E-06 .31564441E-05 -.82070494E-10 -.31703213E-05 .40940604E-06
-.17172117E-05 -.54788625E-05 .15891701E-11 -.54062019E-05 .19338345E-05 -.90655410E-11 -.71395520E-11 -.19852937E-10 .5467837E-06 -.10061491E-10 -.24464605E-10 -.16113739E-05 .23986931E-10 .45635598E-10 .14474359E-04
-.40550995E-04 -.55846279E-04 -.22604313E-10 .55847713E-04 -.40549100E-04 

-.14851140E-11 .40806300E-04 .51925447E-04 .22357522E-10 -.51919354E-04 

.40814116E-04 -.35835384E-10 .15906312E-09 -.16795738E-09 -.21209458E-04 

-.16987299E-03 -.2761947E-03 .11979215E-09 -.27619560E-03 .16987149E-03
-.57726900E-10 -.17376694E-03 -.27781789E-03 .11764036E-09 .27783864E-03
 -.17373411E-03 .70185849E-10
  mass matrix

      .10000000E+01
      -.30291562E-01
      -.76876291E-07
      .73800796E-06
      .32867117E-06

      .13158549E-06
      -.92633251E-08
      -.17952422E-07
      .62673968E-08
      -.19995321E-07

      .20953681E-06
      -.61379992E-07
      .12006683E-09
      -.11753664E-09
      .88805322E-10

      .18582751E-09
      .93589593E-10
      .34601899E-08
      .12520782E-08
      .51220876E-10

-.26895388E-10 -.46932083E-10 -.51456416E-09 -.16699282E-09 -.30291562E-01
.10000000E+01 .26989693E-07 .24701420E-07 .34123181E-05 .19569915E-07
.18126030E-07 -.22083024E-07 -.30895835E-08 -.63797417E-09 .13846796E-06
 -.91584230E-06 .28463240E-09 -.92291186E-09 .13196997E-09 -.83498605E-10 
-.23061102E-09 .37066771E-09 .14015707E-07 .71524564E-09 -.97352491E-12
 -.79781628E-10 -.28504651E-10 -.24628018E-08 -.76876291E-07 .26989693E-07
   .10000000E+01 -.12820039E-07 .23873133E-06 .46502856E-07 .48615925E-08
 -.31587180E-08 -.94997621E-10 -.56075172E-08 .49113872E-08 -.51914907E-07 -.57636964E-11 .45511296E-10 .45041193E-11 -.28608624E-10 .92163317E-11
 -.16290986E-10 .76859350E-09 -.31071312E-10 -.47158520E-11 -.13956592E-11
   .40931813E-11 -.13308932E-09 .73800796E-06 .24701420E-07 -.12820039E-07
  .10000000E+01 .29302137E-02 .10572523E-05 .24430484E-06 .68476034E-07 .92720426E-09 -.64534578E-07 .16242822E-07 .86600013E-08 .72440444E-09 .16245107E-08 -.11209088E-09 .55930229E-10 -.44166054E-09 -.10256621E-08
 -.50144862E-09 -.15880740E-08 .25789654E-09 -.98514653E-10 -.37720327E-09 .27460623E-09 .32867117E-06 .34123181E-05 .23873133E-06 .29302137E-02
   .10000000E+01 .71189247E-06 -.53815780E-06 -.15566832E-05 .83251907E-07
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42741722E-07	.21249170E-12	13940018E+00	12146079E+01 .12958433E-08
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85314857E-12	66967927E-06	.22081894E-06	29618344E-0620740004E-05
.23288741E-06	46545419E-07		73257490E-0732197615E-13 - 15383984E-02 .28931664E+00
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30106500E-09		99735803E-02 .25448515E-06	.24080342E-06 .72100480E-15
.49233010E-09	.98795752E-14 65913199E-09	_ 99837874E-14	
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- 12224359E+00	26190706E-11	.12223122E+00	82113856E-0175550354E-12
49434274E-06	52138355E-06	36084625E-15	.72258733E-08 .45094717E-08
.82984545E-09	.11398262E-07	86245755E-08	84823258E-08 .20012965E+00
.34933873E+00	.29523672E-11		.20008846E+0035514320E-11 .74044170E-0711391547E-06
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.46976639E+00	.13278546E-01	.52285061E-01	23416354E-0635761913E-07
13219075E-05	14943658E-08 35978002E-08	.45661113E-06	.36225913E-0885213715E-08
.301465416-06	87483772E-09	17211154E-07	.12561504E+00 .11934809E-01
.24773363E-01	.28562365E-07	48485096E-09	.38632258E-0920325780E-06
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.40357060E-08		32747580E-08	41693501E-0842365812E-01
22743214E+00	53395066E-09		23299565E-0833531355E-09 .44221408E-0915144278E-09
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	53621168E-07 .71900559E-10	78323733E-07	.95707833E-02 .28472227E-09
40301963E-07	59806850E-09	.30586106E-02	60005167E-09 .27669342E-09
.65749091E-02	.13037445E-06	.21701737E-06	.12705909E-0921430064E-06
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38248253E-U2	- 80376640E-09	30587738E-02	65962710E-0712765379E-06
244452455 00	13611625F-06	- 63215067E-07	.27202374E-09 .16763984E-06
.73009900E-06	- 49745525E-06	- 10506104E-05	54053200E-0630253741E-05
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.20183313E-01		_ 23220378E-06	93398544E-1013727412E-09
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.12962772E+00		.55780767E-10	.34009417E-09 .36617465E-08
.44502412E-08	.82095560E-01	.12224359E+00	.26190706E-11 .53621168E-07 45619868E-07 .18324191E-09
.78323735E-07		35302623E-07	45619868E-07 .18324191E-09 .58936241E-1114505988E-10
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.67860925E-08	11108030E-08	.36522737E-04	
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50488788E-08 .25689226E-08	32032115E-08	12223122E+00 .82113856E-01 71900559E-10 .58945067E-07
.,35303312 12	.40301963E-07	71900559E-10 .58945067E-07 .14505988E-10 .33385669E-02
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.11631316E-1292446699E-02	- 36511561E+00	.12675867E-07 .36422996E+00
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	21239779F-14	17696591E+0039083612E+00
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.15146456E-06 .22667613E-06	27864015E+00	.12645160E-06 .20146267E-06
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27168256E+0017278504E-09	/2258/33E-00	80178997E-0917350601E-08
	.96467007E-07	.10535633E-09 .30329414E-06
65747891E-02 .56730240E-07 .66271809E-06 .35363609E-09	.17696591E+00	.39083612E+00 .84602464E-10
.34515937E-11 .11639133E-10	.11823240E-03	.78122412E-1214089096E-10
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.20000508E-0612631014E-06	30143385E+00	.71358882E-0123320214E-01
.38814806E-07 .48891040E-08	.41439984E-06	.18152134E-0742591726E-06
.27558297E-07 .32855064E-08	.49032229E-08	29885627E-0883085912E-07 12399628E-07 .47190946E-08
.83112891E-0855592945E-08		.16597444E-0850976879E-11
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11154142E-06 .12729912E-07	22012824E-08	16797908E-07 .91574736E-08
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.86245755E-08 .84823258E-08	.60005167E-09	27669342E-0965749091E-02
- 17209949F-08 80376640E-09	.30587738E-02	.91711930E-0755460535E-07
.51525169E-09 .66144997E-06	30804574E-06	20159786E-09 .39083720E+00
17696374E+0030775127E-10	78122412E-12	.14089096E-10 .72836582E-02
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.22679544E-09 .44642344E-07	22809491E-07 .10593951E-05	
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.11419001E+00 .22910605E-07 53138454E-01 .10396571E-06		
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.72527212E-0212256099E-08	79443691E-09	00.630E44B 00
.15892413E-0765356843E-10 20205244E-1139891324E-11	87155679E-04	.84364044E-11 .86915796E-11
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52219327F-06 39275247E-05	.82271192E-08	34017979E-08 .17927404E-06
.52218327E-06 .39275247E-05 - 16399263E-07 .73058140E-08	.82271192E-08 94493068E-01	48349038E-07 .22872252E-07
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.52218327E-06 .39275247E-05 16399263E-07 .73058140E-08 .11390138E+00 .53141657E-01 .26193636E-0618332552E-07	.82271192E-0894493068E-0126904645E-0135360159E-06	48349038E-07 .22872252E-07 .94708623E-07 .55451004E-07 28254188E-07 .38520272E-07
.52218327E-06 .39275247E-05 16399263E-07 .73058140E-08 .11390138E+00 .53141657E-01 .26193636E-0618332552E-07	.82271192E-0894493068E-0126904645E-0135360159E-0689135235E-08	48349038E-07 .22872252E-07 .94708623E-07 .55451004E-07

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  .10387562E-07 -.27226537E-08
                                              .18933107E-09 -.13611625E-06
                .21430064E-06 -.12189418E-06
  35514320E-11
  .63215067E-07 -.27202374E-09 -.76083731E-11 -.16981023E-11 -.72526267E-02
                .57328140E-09 .29238966E-02 -.15032889E-07 .80204827E-08
 -.10976139E-08
 -.24197572E-08 -.31383227E-07 -.10485630E-07 -.42666551E-09 -.44642344E-07
  .22809491E-07 -.59107460E-10 -.84364044E-11 -.86915796E-11 -.68614717E-02
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(and more)

isc3_flex_verneq.int (Concept 1) Vernal Equinox

TREETOPS REV 10P2 4/10/00

SIM CONTROL

1 SI 0 Title 2 SI 0 Simulation stop time ISC MODEL, THIRD VERSION 1000000

Bd Systems® TCD20000222A

29 December 2000

```
20
3 SI 0 Plot data interval
        0 Integration type (R,S,U, OR V)
                                                                1
5 SI 0 Step size (sec)
        O Sandia ODE solver absolute and relative error
 6 SI
       0 RK78 ODE solver absolute error and first step size
 7 SI
       0 Linearization option (L,Z or N)
 8 SI
                                                                N
       0 Restart option (Y/N)
 9 SI
       0 Contact force computation option (Y/N)
10 SI
        0 Constraint force computation option (Y/N)
                                                               N
11 SI
       0 Small angle speedup option (All, Bypass, First, Nth)
12 SI
       0 Mass matrix speedup option (All, Bypass, First, Nth)
13 SI
       0 Non-Linear speedup option (All, Bypass, First, Nth) A
0 Constraint speedup option (All, Bypass, First, Nth) A
14 SI
15 SI
       O Constraint stabilization option (Y/N)
16 SI
17 SI 0 Stabilization epsilon
```

GENGRAV

```
0 Gravity, earth sphere/nonsphere/user (S/N/U)?
                                                              Ν
18 GG
        1 Input gravity constants: GME, ERAD, EMASS
       1 Spherical or Nonspherical (S/N)?
20 GG
       1 Gravity Potential Harmonics J2,J3,J4
21 GG
      O English (ft-slug-s) or metric (m-kg-s)
O Day, Month, Year,
                                                     (E/M)?
                                                              М
22 GG
                                                              20 3 2020
23 GG
                                                              360
       0 GMT @ sim time 0 (minutes past midnight,
24 GG
                                                              Y
       0 Solar Pressure forces Y/N?
25 GG
        0 Input new data for aero model? (Y/N) \,
                                                              N
26 GG
       1 Solar flux F10 for aero model
27 GG
      1 Solar flux, 81 day average F10B
28 GG
      1 Geomagnetic index, GEAP
29 GG
```

BODY

```
1 Body ID number
 31 BO 1 Type (Rigid, Flexible, NASTRAN)
                                                               F
                                                               24
         1 Number of modes
 32 BO
        1 Modal calculation option (0, 1 or 2)
 33 BO
 34 BO 1 Foreshortening option (Y/N)
         1 Model reduction method (NO,MS,MC,CC,QM,CV)
 35 BO
         1 NASTRAN data file FORTRAN unit number (40 - 60)
 36 BO
        1 Number of augmented nodes (0 if none)
 37 BO
        1 Damping matrix option (NS,CD,HL,SD)
 38 BO
         1 Constant damping ratio
 39 BO
        1 Low frequency, High frequency ratios
 40 BO
 41 BO 1 Mode ID number, damping ratio
         1 Conversion factors: Length, Mass, Force
 42 BO
        1 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
 43 BO
                                                               6.2852173E11 6.2852173E11
        1 Moments of inertia (kg-m2) Ixx, Iyy, Izz
 44 BO
6.7057352E8
                                                               0 0 0
 45 BO 1 Products of inertia (kg-m2) Ixy, Ixz, Iyz
                                                               1.6168633E5
        1 Mass (kg)
 46 BO
 47 BO 1 Number of Nodes
                                                               1 0 0 0
         1 Node ID, Node coord. (meters) x,y,z
 48 BO
                                                               2 0 0 0
        1 Node ID, Node coord. (meters) x,y,z
 49 BO
                                                               3 0 0 3188.8
        1 Node ID, Node coord. (meters) x,y,z
 50 BO
        1 Node ID, Node coord. (meters) x,y,z
1 Node ID, Node structual joint ID
                                                               4 0 0 -3188.8
  51 BO
  52 BO
         2 Body ID number
  53 BO
                                                                R
         2 Type (Rigid, Flexible, NASTRAN)
  54 BO
         2 Number of modes
  55 BO
         2 Modal calculation option (0, 1 or 2)
  56 BO
         2 Foreshortening option (Y/N)
  57 BO
         2 Model reduction method (NO,MS,MC,CC,QM,CV)
  58 BO
         2 NASTRAN data file FORTRAN unit number (40 - 60)
```

Contract No. Bd Systems® NAS8-00151 TCD20000222A Final Report 29 December 2000 60 BO 2 Number of augmented nodes (0 if none) 2 Damping matrix option (NS,CD,HL,SD) 62 BO 2 Constant damping ratio 63 BO 2 Low frequency, High frequency ratios 64 BO 2 Mode ID number, damping ratio 65 BO 2 Conversion factors: Length, Mass, Force 66 BO 2 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 2 Moments of inertia (kg-m2) Ixx, Iyy, Izz .8543E12 1.5601E12 67 BO 1.3822E12 0 0 0 68 BO 2 Products of inertia (kg-m2) Ixy, Ixz, Iyz 12666300 69 BO 2 Mass (kg) 2 Number of Nodes 2 Node ID, Node coord. (meters) x,y,z 70 BO 1 298.323 0 0 71 BO 2 0 0 0 72 BO 2 Node ID, Node coord. (meters) x,y,z 3 0 0 300 2 Node ID, Node coord. (meters) x,y,z 73 BO 4 0 0 -300 2 Node ID, Node coord. (meters) x,y,z 74 BO 5 500 0 0 2 Node ID, Node coord. (meters) x,y,z 75 BO 76 BO 2 Node ID, Node structual joint ID 3 77 BO 3 Body ID number R 3 Type (Rigid, Flexible, NASTRAN) 78 BO 3 Modal calculation option (0, 1 or 2) 3 Number of modes 80 BO 3 Foreshortening option (Y/N) 81 BO 3 Model reduction method (NO,MS,MC,CC,QM,CV) 82 BO 3 NASTRAN data file FORTRAN unit number (40 - 60) 83 BO 3 Number of augmented nodes (0 if none) 3 Damping matrix option (NS,CD,HL,SD) 84 BO 85 BO 3 Constant damping ratio 3 Low frequency, High frequency ratios 87 BO 3 Mode ID number, damping ratio 88 BO 3 Conversion factors: Length, Mass, Force 89 BO 3 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 90 BO 3 Moments of inertia (kg-m2) Ixx, Iyy, Izz 1.7E12 1.7E12 3.4E12 3 Products of inertia (kg-m2) Ixy, Ixz, Iyz 0 0 0 91 BO 0 0 2 2046600 92 BO 93 BO 3 Mass (kg) 3 Number of Nodes 94 BO 1 0 0 0 3 Node ID, Node coord. (meters) x,y,z 95 BO 96 BO 3 Node ID, Node coord. (meters) x,y,z 2 0 0 0 97 BO 3 Node ID, Node structual joint ID 4 98 BO 4 Body ID number R 99 BO 4 Type (Rigid, Flexible, NASTRAN) 100 BO 4 Number of modes 101 BO 4 Modal calculation option (0, 1 or 2) 102 BO 4 Foreshortening option (Y/N)103 BO 4 Model reduction method (NO,MS,MC,CC,QM,CV) 104 BO 4 NASTRAN data file FORTRAN unit number (40 - 60) 105 BO 4 Number of augmented nodes (0 if none) 106 BO 4 Damping matrix option (NS,CD,HL,SD) 107 BO 4 Constant damping ratio 108 BO 4 Low frequency, High frequency ratios 109 BO 4 Mode ID number, damping ratio 110 BO 4 Conversion factors: Length, Mass, Force 111 BO 4 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
112 BO 4 Moments of inertia (kg-m2) Ixx,Iyy,Izz 1.7E12 1.7E12 3.4E12
113 BO 4 Products of inertia (kg-m2) Ixy,Ixz,Iyz 0 0 0 113 BO 4 Products of inertia (kg-m2) Ixy, Ixz, Iyz 2046600 114 BO 4 Mass (kg) 115 BO 4 Number of Nodes 1 0 0 0 4 Node ID, Node coord. (meters) x,y,z 116 BO 2 0 0 0 117 BO 4 Node ID, Node coord. (meters) x,y,z 118 BO 4 Node ID, Node structual joint ID HINGE 119 HI 1 Hinge ID number 120 HI 1 Inboard body ID, Outboard body ID 1 "p" node ID, "q" node ID 1 Number of rotation DOFs, Rotation option (F or G) 0 2 121 HI 122 HI 1 L1 unit vector in inboard body coord. x,y,z

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29 December 2000 124 HI 1 L1 unit vector in outboard body coord. x,y,z 1 0 0 125 HI 1 L2 unit vector in inboard body coord. x,y,z 126 HI 1 L2 unit vector in outboard body coord. x,y,z 127 HI 1 L3 unit vector in inboard body coord. x,y,z
128 HI 1 L3 unit vector in outboard body coord. x,y,z
129 HI 1 Initial rotation angles (deg) 0 0 1 0 0 1 -90. 0. 0. 130 HI 1 Initial rotation rates (deg/sec) 131 HI 1 Rotation stiffness (newton-meters/rad)
132 HI 1 Rotation damping (newton-meters/rad/sec) 0 0 0 0 0 0 0 0 0 133 HI 1 Null torque angles (deg) 133 HI 1 Null torque angles (deg/
134 HI 1 Number of translation DOFs
135 HI 1 First translation unit vector g1
136 HI 1 Second translation unit vector g2
137 HI 1 Third translation unit vector g3 1 0 0 0 1 0 0 0 1 138 HI 1 Initial translation (meters)
139 HI 1 Initial translation velocity (meters/sec) 0 0 42163421 3074.681 0 0 139 HI 1 initial translation vectors, (meters)
140 HI 1 Translation stiffness (newtons/meters) 0 0 0 141 HI 1 Translation damping (newtons/meter/sec)
142 HI 1 Null force translations 0 0 0 0 0 0 143 HI 2 Hinge ID number 144 HI 2 Inboard body ID, Outboard body ID 145 HI 2 "p" node ID, "q" node ID 146 HI 2 Number of rotation DOFs 1 2 147 HI 2 L1 unit vector in inboard body coord. x,y,z 0 0 1 148 HI 2 L1 unit vector in outboard body coord. x,y,z 149 HI 2 L2 unit vector in inboard body coord. x,y,z 0 0 1 150 HI 2 L2 unit vector in outboard body coord. x,y,z 151 HI 2 L3 unit vector in inboard body coord. x,y,z 1 0 0 1 0 0 152 HI 2 L3 unit vector in outboard body coord. x,y,z 153 HI 2 Initial rotation angles (deg) 90. 0. 0. 154 HI 2 Initial rotation rates (deg/sec) 0.00417807 155 HI 2 Rotation stiffness (newton-meters/rad)
156 HI 2 Rotation damping (newton-meters/rad/sec)
157 HI 2 Null torque angles (deg) 0 158 HI 2 Number of translation DOFs 159 HI 2 First translation unit vector g1
160 HI 2 Second translation unit vector g2
161 HI 2 Third translation unit vector g3 1 0 0 0 1 0 0 0 1 161 HI 2 Third translation unit vector g3 162 HI 2 Initial translation (meters) 0 0 0 163 HI 2 Initial translation velocity (meters/sec)
164 HI 2 Translation stiffness (newtons/meters) 165 HI 2 Translation damping (newtons/meter/sec) 166 HI 2 Null force translations 167 HI 3 Hinge ID number 168 HI 3 Inboard body ID, Outboard body ID 169 HI 3 "p" node ID, "q" node ID 170 HI 3 Number of rotation DOFs 1 3 3 2 171 HI 3 L1 unit vector in inboard body coord. x,y,z 0 0 1 172 HI 3 L1 unit vector in outboard body coord. x,y,z
173 HI 3 L2 unit vector in inboard body coord. x,y,z 0 0 1 174 HI 3 L2 unit vector in outboard body coord. x,y,z 175 HI 3 L3 unit vector in inboard body coord. x,y,z
176 HI 3 L3 unit vector in outboard body coord. x,y,z
177 HI 3 Initial rotation angles (deg)
0. 0. 0. 0. -135. 178 HI 3 Initial rotation rates (deg/sec) 179 HI 3 Rotation stiffness (newton-meters/rad)
180 HI 3 Rotation damping (newton-meters/rad/sec) 181 HI 3 Null torque angles (deg) 182 HI 3 Number of translation DOFs
183 HI 3 First translation unit vector g1
184 HI 3 Second translation unit vector g2 1 0 0 0 1 0 0 0 1 185 HI 3 Third translation unit vector g3 186 HI 3 Initial translation (meters)
187 HI 3 Initial translation velocity (meters/sec) 0 0 0 188 HI 3 Translation stiffness (newtons/meters) 189 HI 3 Translation damping (newtons/meter/sec)
190 HI 3 Null force translations

191 HI 4 Hinge ID number

```
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                                                                      1 4
 192 HI 4 Inboard body ID, Outboard body ID
          4 "p" node ID, "q" node ID
 193 HI
 194 HI 4 Number of rotation DOFs
 195 HI 4 L1 unit vector in inboard body coord. x,y,z
                                                                      0 0 1
 196 HI 4 L1 unit vector in outboard body coord. x,y,z
197 HI 4 L2 unit vector in inboard body coord. x,y,z
                                                                      0 0 1
 198 HI 4 L2 unit vector in outboard body coord. x,y,z
 199 HI 4 L3 unit vector in inboard body coord. x,y,z
                                                                   0 1 0
          4 L3 unit vector in outboard body coord. x,y,z
                                                                      0 1 0
 200 HI
                                                                      0. 0. -45.
 201 HI 4 Initial rotation angles (deg)
 202 HI 4 Initial rotation rates (deg/sec)
 203 HI 4 Rotation stiffness (newton-meters/rad)
204 HI 4 Rotation damping (newton-meters/rad/sec)
 205 HI 4 Null torque angles (deg)
 206 HI 4 Number of translation DOFs
 207 HI 4 First translation unit vector g1
208 HI 4 Second translation unit vector g2
                                                                      1 0 0
                                                                      0 1 0
                                                                      0 0 1
 209 HI 4 Third translation unit vector g3
 210 HI 4 Initial translation (meters)
211 HI 4 Initial translation velocity (meters/sec)
212 HI 4 Translation stiffness (newtons/meters)
                                                                      0 0 0
 213 HI 4 Translation damping (newtons/meter/sec)
 214 HI 4 Null force translations
             SENSOR
         1 Sensor ID number
 215 SE
 216 SE 1 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ET
 217 SE 1 Mounting point body ID, Mounting point node ID
           1 Second mounting point body ID, Second node ID
          1 Input axis unit vector (IA) x,y,z
 219 SE
          1 Mounting point Hinge index, Axis index
 220 SE
 221 SE 1 First focal plane unit vector (Fp1) x,y,z
222 SE 1 Second focal plane unit vector (Fp2) x,y,z
                                                                  0 0 -1
                                                                       0 1 0
 223 SE 1 Sun/Star unit vector (Us) x,y,z
 224 SE 1 Velocity Aberration Option (Y/N)
           1 Euler Angle Sequence (1-6)
 225 SE
          1 CMG ID number and Gimbal number
 226 SE
                                                                       6378000 0 0 4.178074D-3
 227 SE 1 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
 228 SE 2 Sensor ID number
 229 SE 2 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST
 230 SE 2 Mounting point body ID, Mounting point node ID
 231 SE 2 Second mounting point body ID, Second node ID 232 SE 2 Input axis unit vector (IA) x,y,z
 233 SE 2 Mounting point Hinge index, Axis index
 234 SE 2 First focal plane unit vector (Fp1) x,y,z
235 SE 2 Second focal plane unit vector (Fp2) x,y,z
                                                                       0 - 1 0
                                                                       1 0 0
                                                                       0 1 0
 236 SE 2 Sun/Star unit vector (Us) x,y,z
 237 SE 2 Velocity Aberration Option (Y/N)
           2 Euler Angle Sequence (1-6)
 238 SE
 238 SE 2 Euler Angle Sequence (1-6)
239 SE 2 CMG ID number and Gimbal number
 240 SE 2 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
 241 SE 3 Sensor ID number
 242 SE 3 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST
 243 SE 3 Mounting point body ID, Mounting point node ID
           3 Second mounting point body ID, Second node ID
 244 SE
 245 SE 3 Input axis unit vector (IA) x,y,z
 246 SE 3 Mounting point Hinge index, Axis index
 247 SE 3 First focal plane unit vector (Fp1) x,y,z
248 SE 3 Second focal plane unit vector (Fp2) x,y,z
                                                                       -1 0 0
                                                                       0 0 1
                                                                       0 0 0
 249 SE 3 Sun/Star unit vector (Us) x,y,z
 250 SE 3 Velocity Aberration Option (Y/N)
           3 Euler Angle Sequence (1-6)
 251 SE
  252 SE 3 CMG ID number and Gimbal number
  253 SE 3 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
           4 Sensor ID number
  254 SE
  255 SE 4 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) A3
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29 December 2000 4 Mounting point body ID, Mounting point node ID 256 SE 4 Second mounting point body ID, Second node ID 4 Input axis unit vector (IA) x,y,z 4 Mounting point Hinge index, Axis index 259 SE 4 First focal plane unit vector (Fp1) x,y,z 260 SE 4 Second focal plane unit vector (Fp2) x,y,z 261 SE 4 Sun/Star unit vector (Us) x,y,z 262 SE 4 Velocity Aberration Option (Y/N) 263 SE 4 Euler Angle Sequence (1-6) 264 SE 4 CMG ID number and Gimbal number 265 SE 4 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 266 SE 5 Sensor ID number 267 SE 5 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) LV 268 SE 5 Mounting point body ID, Mounting point node ID 269 SE 5 Second mounting point body ID, Second node ID 270 SE 5 Input axis unit vector (IA) x,y,z 271 SE 5 Mounting point Hinge index, Axis index 272 SE 5 First focal plane unit vector (Fp1) x,y,z 273 SE 5 Second focal plane unit vector (Fp2) x,y,z 274 SE 5 Sun/Star unit vector (Us) x,y,z 275 SE 5 Velocity Aberration Option (Y/N) 276 SE 5 Euler Angle Sequence (1-6) 277 SE 5 CMG ID number and Gimbal number 278 SE 5 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 279 SE 6 Sensor ID number 280 SE 6 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV L 281 SE 6 Mounting point body ID, Mounting point node ID 282 SE 6 Second mounting point body ID, Second node ID 283 SE 1 0 0 6 Input axis unit vector (IA) x,y,z 284 SE 6 Mounting point Hinge index, Axis index 285 SE 6 First focal plane unit vector (Fp1) x,y,z 286 SE 6 Second focal plane unit vector (Fp2) x,y,z 287 SE 6 Sun/Star unit vector (Us) x,y,z 288 SE 6 Velocity Aberration Option (Y/N) 289 SE 290 SE 6 Euler Angle Sequence (1-6) 6 CMG ID number and Gimbal number 291 SE 6 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 292 SE 293 SE 7 Sensor ID number 294 SE 7 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV L 7 Mounting point body ID, Mounting point node ID 7 Second mounting point body ID, Second node ID 296 SE 7 Input axis unit vector (IA) x,y,z 297 SE 7 Mounting point Hinge index, Axis index 298 SE 7 First focal plane unit vector (Fp1) x,y,z 7 Second focal plane unit vector (Fp2) x,y,z 299 SE 300 SE 301 SE 7 Sun/Star unit vector (Us) x,y,z 7 Velocity Aberration Option (Y/N) 302 SE 7 Euler Angle Sequence (1-6) 303 SE 7 CMG ID number and Gimbal number 304 SE 7 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 305 SE ACTR 1 1 Actuator ID number 306 AC 1 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) MO 307 AC 1 Actuator location; Node or Hinge (N or H) 308 AC 1 Mounting point body ID number, node ID number 2 2 309 AC 1 Second mounting point body ID, second node ID 310 AC 0 1 0 311 AC 1 Output axis unit vector x,y,z 1 Mounting point Hinge index, Axis index 312 AC 1 Rotor spin axis unit vector x,y,z 313 AC 1 Initial rotor momentum, H 314 AC 1 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 315 AC 1 Outer gimbal axis unit vector x,y,z 316 AC 1 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 317 AC 1 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 318 AC 1 Inner gimbal axis unit vector x,y,z

Bd Systems® TCD20000222A 29 December 2000 1 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 320 AC 1 Initial length and rate, y(to) and ydot(to) 1 Constants; K1 or wo, n or zeta, Kg, Jm 1 Non-linearities; TLim, Tco, Dz 2 Actuator ID number 324 AC MO 2 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 325 AC 2 Actuator location; Node or Hinge (N or H) 326 AC 2 Mounting point body ID number, node ID number 327 AC 2 Second mounting point body ID, second node ID 328 AC 0 0 1 2 Output axis unit vector x,y,z 329 AC 2 Mounting point Hinge index, Axis index 330 AC 2 Rotor spin axis unit vector x,y,z 331 AC 2 Initial rotor momentum, H 332 AC 2 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 333 AC 2 Outer gimbal axis unit vector x,y,z 334 AC 2 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 335 AC 2 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 336 AC 2 Inner gimbal axis unit vector x,y,z 337 AC 2 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 338 AC 2 Initial length and rate, y(to) and ydot(to)339 AC 2 Constants; K1 or wo, n or zeta, Kg, Jm 340 AC 2 Non-linearities; TLim, Tco, Dz 341 AC 342 AC 3 Actuator ID number MO 3 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 343 AC 3 Actuator location; Node or Hinge (N or H) 344 AC 3 Mounting point body ID number, node ID number 2 2 345 AC 3 Second mounting point body ID, second node ID 346 AC 1 0 0 3 Output axis unit vector x,y,z 347 AC 3 Mounting point Hinge index, Axis index 348 AC 3 Rotor spin axis unit vector x,y,z 349 AC 3 Initial rotor momentum, H 350 AC 3 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 351 AC 3 Outer gimbal axis unit vector x,y,z 352 AC 3 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)353 AC 3 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 354 AC 3 Inner gimbal axis unit vector x,y,z 355 AC 3 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 356 AC 3 Initial length and rate, y(to) and ydot(to) 357 AC 3 Constants; K1 or wo, n or zeta, Kg, Jm 358 AC 359 AC 3 Non-linearities; TLim, Tco, Dz 4 360 AC 4 Actuator ID number 4 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Т 361 AC 4 Actuator location; Node or Hinge (N or H) 362 AC 4 Mounting point body ID number, node ID number 363 AC 4 Second mounting point body ID, second node ID 364 AC 365 AC 4 Output axis unit vector x,y,z 2 1 4 Mounting point Hinge index, Axis index 366 AC 4 Rotor spin axis unit vector x,y,z 367 AC 4 Initial rotor momentum, H 368 AC 4 Outer gimbal- angle(deg), inertia, friction(D,S,B,N) 369 AC 4 Outer gimbal axis unit vector x,y,z 370 AC 4 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 371 AC 4 Inner gimbal- angle(deg), inertia, friction(D,S,B,N) 372 AC 4 Inner gimbal axis unit vector x,y,z 373 AC 4 In gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 374 AC 4 Initial length and rate, y(to) and ydot(to) 375 AC 4 Constants; K1 or wo, n or zeta, Kg, Jm 376 AC 4 Non-linearities; TLim, Tco, Dz 377 AC 5 5 Actuator ID number 378 AC 5 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) J 379 AC 5 Actuator location; Node or Hinge (N or H) 380 AC 2 5 5 Mounting point body ID number, node ID number 381 AC 5 Second mounting point body ID, second node ID 382 AC -1 0 0 5 Output axis unit vector x,y,z 383 AC 5 Mounting point Hinge index, Axis index 384 AC 5 Rotor spin axis unit vector x,y,z 385 AC 5 Initial rotor momentum, H

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Bd Systems® TCD20000222A 29 December 2000 5 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 5 Outer gimbal axis unit vector x,y,z 389 AC 5 Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 5 Inner gimbal- angle(deg), inertia, friction(D,S,B,N) 390 AC 5 Inner gimbal axis unit vector x,y,z 391 AC 5 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 392 AC 5 Initial length and rate, y(to) and ydot(to) 393 AC 5 Constants; K1 or wo, n or zeta, Kg, Jm 394 AC 395 AC 5 Non-linearities; TLim, Tco, Dz CONTROLLER 1 1 Controller ID number 396 CO CM1 Controller type (CB,CM,DB,DM,UC,UD) 397 CO 1 Sample time (sec) 4 4 1 Number of inputs, Number of outputs 399 CO 1 Number of states 400 CO 1 Output No., Input type (I,S,T), Input ID, Gain 401 CO INTERCONNECT 1 1 Interconnect ID number 402 IN 1 Source type(S,C, or F), Source ID, Source row # S 1 1 403 IN 1 Destination type(A or C), Dest ID, Dest row # 1 Gain C 1 1 404 IN 4.41E13 405 IN 2 Interconnect ID number 406 IN 2 Source type(S,C, or F),Source ID,Source row # C 1 1 407 IN A 1 1 2 Destination type(A or C), Dest ID, Dest row # 408 IN 1 409 IN 3 410 IN 3 Interconnect ID number S 1 2 411 IN 3 Source type(S,C, or F), Source ID, Source row # 3 Destination type(A or C),Dest ID,Dest row # C 1 2 412 IN 1.67E12 3 Gain 413 IN 414 IN 4 Interconnect ID number C 1 2 4 Source type(S,C, or F),Source ID,Source row # 415 IN 4 Destination type(A or C), Dest ID, Dest row # 4 Gain A 2 1 416 IN 417 IN 5 5 Interconnect ID number 418 TN 5 Source type(S,C, or F), Source ID, Source row # S 2 1 419 IN C 1 3 5 Destination type(A or C), Dest ID, Dest row # 420 IN 4.31E13 421 IN 5 Gain 6 Interconnect ID number 422 IN 6 Source type(S,C, or F),Source ID,Source row # C 1 3 6 Destination type(A or C), Dest ID, Dest row # 6 Gain A 3 1 424 IN 1 425 IN 7 Interconnect ID number 426 IN 7 Source type(S,C, or F), Source ID, Source row # S 3 1 427 IN C 1 4 7 Destination type(A or C), Dest ID, Dest row # 428 IN 6.7E8 7 Gain 429 IN 8 Interconnect ID number 8 Source type(S,C, or F),Source ID,Source row # C 1 4 431 IN 432 IN 8 Destination type(A or C), Dest ID, Dest row # A 4 1 1 433 IN 8 Gain 434 IN 9 Interconnect ID number 9 Source type(S,C, or F), Source ID, Source row # s 3 3 435 IN

9 Destination type(A or C), Dest ID, Dest row #

436 IN

437 IN 9 Gain

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A 5 1

isc3_flex_autmeq.int (Concept 1) Autumnal Equinox

TREETOPS REV 10P2 4/10/00

SIM CONTROL

1	SI	ን ጥ-	itle	ISC MODEL, THIRD VERSION
	-		imulation stop time	100000
			lot data interval	20
	SI) F.	ntegration type (R,S,U, OR V)	R
	SI) 51	tep size (sec)	.1
	SI	ים כי	andia ODE solver absolute and relative error	
	51	ום כ	K78 ODE solver absolute error and first step size	
	SI	יז כ	inearization option (L,Z or N)	N
			estart option (Y/N)	N
	SI	י עי	ontact force computation option (Y/N)	Y
10	21	ח כי	onstraint force computation option (Y/N)	N
11	SI	ט כי	mall angle speedup option (All, Bypass, First, Nth)	A
12	SI	0 5	ass matrix speedup option (All, Bypass, First, Nth)	A
13	51	O M	on-Linear speedup option (All, Bypass, First, Nth)	A
14	51	O O	onstraint speedup option (All, Bypass, First, Nth)	A
15	SI	0 0	onstraint speedup option (MIT, 5, pass,) onstraint stabilization option (Y/N)	N
16	SI	0 0	Onstraint stabilization operon (1747)	
17	SI	0 5	tabilization epsilon	
		_	DNICD AT	
		G	ENGRAV	
	~~		ravity, earth sphere/nonsphere/user (S/N/U)?	N
18	GG	0 G	nput gravity constants: GME, ERAD, EMASS	
19	GG	1 1:	nput gravity constants: GHE, ERAD, MINES	
20	GG	1 S	pherical or Nonspherical (S/N)?	
	GG	1 G	ravity Potential Harmonics J2, J3, J4	М
22	GG	0 E	ingrish (ic-sing b) or meeric (in is	20 9 2020
	GG	0 D	Day, Month, Year,	360
	GG	0 G	MT @ sim time 0 (minutes past midnight,	Y
	GG	0 S	Solar Pressure forces Y/N?	N
			input new data for aero model? (Y/N)	14
		1	Solar flux F10 for aero model	
		1	Solar flux, 81 day average F10B	
29	GG		Geomagnetic index, GEAP	
		1		
2,		1		
2,5				
2,5			BODY	
2,				
		В	BODY	1
30	во	В 1 В	BODY Body ID number	1 F
30 31	BO BO	B 1 B 1 T	BODY Body ID number Type (Rigid,Flexible,NASTRAN)	
30 31 32	BO BO BO	B 1 B 1 T	BODY Body ID number Type (Rigid,Flexible,NASTRAN) Dumber of modes	F
30 31 32 33	BO BO BO	B 1 B 1 T 1 N 1 M	BODY Body ID number Type (Rigid,Flexible,NASTRAN) Jumber of modes Jodal calculation option (0, 1 or 2)	F 24
30 31 32 33 34	BO BO BO BO	B 1 B 1 T 1 N 1 M	Body ID number Type (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2)	F 24
30 31 32 33 34 35	BO BO BO BO BO	B 1 B 1 T 1 N 1 M 1 F	Body ID number Type (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Foreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV)	F 24
30 31 32 33 34 35 36	BO BO BO BO BO BO	B 1 B 1 T 1 N 1 M 1 F 1 M	Gody ID number Gype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Goreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) MASTRAN data file FORTRAN unit number (40 - 60)	F 24
30 31 32 33 34 35 36 37	BO BO BO BO BO BO BO	1 B 1 T 1 N 1 M 1 F 1 N 1 N	Gody ID number Gype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Goreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none)	F 24
30 31 32 33 34 35 36 37 38	BO BO BO BO BO BO BO BO	B 1 B 1 T 1 N 1 M 1 F 1 N 1 N 1 N	Gody ID number Gype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Goreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS,CD,HL,SD)	F 24
30 31 32 33 34 35 36 37 38 39	BO BO BO BO BO BO BO BO	B 1 B 1 T 1 N 1 M 1 N 1 N 1 N 1 N 1 N	Body ID number Cype (Rigid, Flexible, NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Foreshortening option (Y/N) Model reduction method (NO, MS, MC, CC, QM, CV) MASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Compting matrix option (NS, CD, HL, SD) Constant damping ratio	F 24
30 31 32 33 34 35 36 37 38 39	BO BO BO BO BO BO BO BO BO	B 1 B 1 T 1 N 1 F 1 N 1 N 1 D 1 C 1 L	Body ID number Cype (Rigid, Flexible, NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Foreshortening option (Y/N) Model reduction method (NO, MS, MC, CC, QM, CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS, CD, HL, SD) Constant damping ratio Low frequency, High frequency ratios	F 24
30 31 32 33 34 35 36 37 38 40 41	BO BO BO BO BO BO BO BO BO BO	B 1 B 1 T 1 N 1 M 1 F 1 N 1 D 1 C 1 L	Gody ID number Cype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Coreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS,CD,HL,SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio	F 24 2
30 31 32 33 34 35 36 37 38 39 40 41	BO BO BO BO BO BO BO BO BO BO BO	B 1 B 1 T 1 N 1 M 1 F 1 N 1 D 1 C 1 L	Gody ID number Cype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Coreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS,CD,HL,SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio	F 24 2
30 31 32 33 34 35 36 37 38 39 41 42 43	BO BO BO BO BO BO BO BO BO BO BO BO	B 1 B 1 T 1 N 1 M 1 N 1 D 1 C 1 I 1 M 1 C 1 I 1 T	Gody ID number Cype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Coreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS,CD,HL,SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio Conversion factors: Length, Mass,Force Unertia reference node (0=Bdy Ref Frm; 1=mass cen)	F 24 2
30 31 32 33 34 35 36 37 38 39 40 41 42 43	BO BO BO BO BO BO BO BO BO BO BO BO	B 1 B 1 T 1 N 1 M 1 F 1 N 1 N 1 D 1 C 1 I 1 M 1 C 1 I 1 M	Gody ID number Cype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Coreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS,CD,HL,SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio	F 24 2
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 6.70	BO BO BO BO BO BO BO BO BO BO BO BO BO	B 1 B 1 T 1 N 1 M 1 F 1 N 1 N 1 D 1 C 1 L 1 M 1 C 1 I 1 M 1 M 1 C 1 I 1 M 1 M 1 C 1 I 1 M 1 M 1 C 1 I 1 M 1 M 1 M 1 M 1 M 1 M 1 M 1 M 1 M 1 M	Gody ID number Cype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Foreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS,CD,HL,SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio Conversion factors: Length,Mass,Force Inertia reference node (0=Bdy Ref Frm; 1=mass cen) Moments of inertia (kg-m2) Ixx,Iyy,Izz	F 24 2
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 6.70 45	BO BO BO BO BO BO BO BO BO BO BO BO BO B	B 1 B 1 T 1 N 1 M 1 F 1 N 1 N 1 D 1 C 1 I 1 M 1 C 1 I 1 M 1 C 1 I 1 M 1 C 1 I 1 M 1 C 1 I 1 M 1 C 1 I 1 M 1 C 1 I 1 M 1 C 1 I 1 M 1 C 1 I 1 M 1 C 1 I 1 M 1 C 1 I 1 M 1 M 1 I 1 M 1 M 1 I 1 M 1 M 1 M 1 M 1 M 1 M 1 M 1 M 1 M 1 M	Gody ID number Cype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Coreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS,CD,HL,SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio Conversion factors: Length, Mass,Force Inertia reference node (0=Bdy Ref Frm; 1=mass cen) Moments of inertia (kg-m2) Ixx,Iyy,Izz	F 24 2
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 6.70 45	BO BO BO BO BO BO BO BO BO BO BO BO BO B	B B 1 B 1 T T 1 N M 1 1 F T 1 N M 1 1 T T 1 N M 1 1 T T 1 T M 1 1 T T 1 T M 1 T T 1 T M 1 T T T T	BODY Body ID number Cype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Foreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS,CD,HL,SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio Conversion factors: Length,Mass,Force Inertia reference node (0=Bdy Ref Frm; 1=mass cen) Moments of inertia (kg-m2) Ixx,Iyy,Izz Products of inertia (kg-m2) Ixy,Ixz,Iyz Mass (kg)	F 24 2 1 6.2852173E11 6.2852173E11 0 0 0 1.6168633E5 4
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 6.70 45 46	BO BO BO BO BO BO BO BO BO BO BO BO BO B	B B B B B B B B B B B B B B B B B B B	Body ID number Cype (Rigid, Flexible, NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Foreshortening option (Y/N) Model reduction method (NO, MS, MC, CC, QM, CV) MASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS, CD, HL, SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio Conversion factors: Length, Mass, Force Inertia reference node (0=Bdy Ref Frm; 1=mass cen) Moments of inertia (kg-m2) Ixx, Iyy, Izz Products of inertia (kg-m2) Ixy, Ixz, Iyz Mass (kg) Number of Nodes	F 24 2 1 6.2852173E11 6.2852173E11 0 0 0 1.6168633E5
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 6.70 45 46 47 48	BO BO BO BO BO BO BO BO BO BO BO BO BO B	B 1 B 1 T 1 N 1 M 1 F 1 N 1 C 1 L 1 M 2 C 1 F 1 M 2 C 1 F 1 M 1 N 1 N 1 N 1 N 1 N 1 N 1 N 1 N 1 N 1 N	Body ID number Cype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Foreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) MASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS,CD,HL,SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio Conversion factors: Length,Mass,Force Inertia reference node (0=Bdy Ref Frm; 1=mass cen) Moments of inertia (kg-m2) Ixx,Iyy,Izz Products of inertia (kg-m2) Ixy,Ixz,Iyz Mass (kg) Number of Nodes Node ID, Node coord. (meters) x,y,z	F 24 2 1 6.2852173E11 6.2852173E11 0 0 0 1.6168633E5 4 1 0 0 0 2 0 0 0
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 6.70 45 46 47 48	BO BO BO BO BO BO BO BO BO BO BO BO BO B	B 1 B 1 T 1 N 1 M 1 F 1 N 1 C 1 L 1 M 1 C 1 L 1 M 1 C 1 I 1 M 1 N 1 N 1 I 1 M 1 N 1 I 1 M 1 N 1 I 1 M 1 N 1 I 1 M 1 N 1 I 1 M 1 N 1 M 1 N 1 M 1 N 1 N 1 N 1 N 1 N 1 N 1 N 1 N 1 N 1 N	Body ID number Cype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Foreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Compaining matrix option (NS,CD,HL,SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio Conversion factors: Length,Mass,Force Inertia reference node (0=Bdy Ref Frm; 1=mass cen) Moments of inertia (kg-m2) Ixx,Iyy,Izz Peroducts of inertia (kg-m2) Ixy,Ixz,Iyz Mass (kg) Number of Nodes Node ID, Node coord. (meters) x,y,z Node ID, Node coord. (meters) x,y,z	F 24 2 1 6.2852173E11 6.2852173E11 0 0 0 1.6168633E5 4 1 0 0 0 2 0 0 0 3 0 0 3188.8
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 6.70 45 46 47 48 49 50	BO BO BO BO BO BO BO BO BO BO BO BO BO B	B 1 B 1 T 1 N 1 M 1 F 1 N 1 D 1 D 1 D 1 D 1 D 1 D 1 D 1 D 1 D 1 D	Body ID number Cype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Foreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS,CD,HL,SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio Conversion factors: Length,Mass,Force Inertia reference node (0=Bdy Ref Frm; 1=mass cen) Moments of inertia (kg-m2) Ixx,Iyy,Izz Products of inertia (kg-m2) Ixx,Iyy,Izz Products of Nodes Node ID, Node coord. (meters) x,y,z Node ID, Node coord. (meters) x,y,z Node ID, Node coord. (meters) x,y,z	F 24 2 1 6.2852173E11 6.2852173E11 0 0 0 1.6168633E5 4 1 0 0 0 2 0 0 0
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 6.70 45 46 47 48 49 50 51	BO BO BO BO BO BO BO BO BO BO BO BO BO B	B 1 B 1 T 1 N 1 M 1 F 1 N 1 I 1 N 1 I 1 I 1 I 1 I 1 I 1 I 1 I 1 I 1 I 1 I	Gody ID number Pype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Poreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) MASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS,CD,HL,SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio Conversion factors: Length,Mass,Force Inertia reference node (0=Bdy Ref Frm; 1=mass cen) Moments of inertia (kg-m2) Ixx,Iyy,Izz Products of inertia (kg-m2) Ixy,Ixz,Iyz Mass (kg) Number of Nodes Node ID, Node coord. (meters) x,y,z	F 24 2 1 6.2852173E11 6.2852173E11 0 0 0 1.6168633E5 4 1 0 0 0 2 0 0 0 3 0 0 3188.8
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 6.70 45 46 47 48 49 50 51	BO BO BO BO BO BO BO BO BO BO BO BO BO B	B 1 B 1 T 1 N 1 M 1 F 1 N 1 I 1 N 1 I 1 I 1 I 1 I 1 I 1 I 1 I 1 I 1 I 1 I	Body ID number Cype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Foreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS,CD,HL,SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio Conversion factors: Length,Mass,Force Inertia reference node (0=Bdy Ref Frm; 1=mass cen) Moments of inertia (kg-m2) Ixx,Iyy,Izz Products of inertia (kg-m2) Ixx,Iyy,Izz Products of Nodes Node ID, Node coord. (meters) x,y,z Node ID, Node coord. (meters) x,y,z Node ID, Node coord. (meters) x,y,z	F 24 2 2 1 6.2852173E11 6.2852173E11 0 0 0 1.6168633E5 4 1 0 0 0 2 0 0 0 3 0 0 3188.8 4 0 0 -3188.8
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52	BO BO BO BO BO BO BO BO BO BO BO BO BO B	B B B I T T I N N I I I N N I I I I N N I I I I	Gody ID number Cype (Rigid, Flexible, NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Foreshortening option (Y/N) Model reduction method (NO, MS, MC, CC, QM, CV) NASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS, CD, HL, SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio Conversion factors: Length, Mass, Force Inertia reference node (0=Bdy Ref Frm; 1=mass cen) Moments of inertia (kg-m2) Ixx, Iyy, Izz Products of inertia (kg-m2) Ixy, Ixz, Iyz Mass (kg) Number of Nodes Node ID, Node coord. (meters) x,y,z Node ID, Node structual joint ID	F 24 2 1 6.2852173E11 6.2852173E11 0 0 0 1.6168633E5 4 1 0 0 0 2 0 0 0 3 0 0 3188.8 4 0 0 -3188.8
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 6.700 45 46 47 48 49 50 51 52	BO BO BO BO BO BO BO BO BO BO BO BO BO B	B B T T N N D C C C C C C C C C C C C C C C C C	Gody ID number Pype (Rigid,Flexible,NASTRAN) Number of modes Modal calculation option (0, 1 or 2) Poreshortening option (Y/N) Model reduction method (NO,MS,MC,CC,QM,CV) MASTRAN data file FORTRAN unit number (40 - 60) Number of augmented nodes (0 if none) Damping matrix option (NS,CD,HL,SD) Constant damping ratio Low frequency, High frequency ratios Mode ID number, damping ratio Conversion factors: Length,Mass,Force Inertia reference node (0=Bdy Ref Frm; 1=mass cen) Moments of inertia (kg-m2) Ixx,Iyy,Izz Products of inertia (kg-m2) Ixy,Ixz,Iyz Mass (kg) Number of Nodes Node ID, Node coord. (meters) x,y,z	F 24 2 2 1 6.2852173E11 6.2852173E11 0 0 0 1.6168633E5 4 1 0 0 0 2 0 0 0 3 0 0 3188.8 4 0 0 -3188.8

Contract No. Bd Systems® NAS8-00151 TCD20000222A Final Report 29 December 2000 55 BO 2 Number of modes 56 BO 2 Modal calculation option (0, 1 or 2) 57 BO $\,$ 2 Foreshortening option (Y/N) 58 BO 2 Model reduction method (NO,MS,MC,CC,QM,CV) 2 NASTRAN data file FORTRAN unit number (40 - 60) 60 BO 2 Number of augmented nodes (0 if none) 61 BO 2 Damping matrix option (NS,CD,HL,SD) 2 Constant damping ratio 62 BO 2 Low frequency, High frequency ratios 63 BO 64 BO 2 Mode ID number, damping ratio 65 BO 2 Conversion factors: Length, Mass, Force 66 BO 2 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 67 BO 2 Moments of inertia (kg-m2) Ixx,Iyy,Izz .8543E12 1.5601E12 1.3822E12 0 0 0 68 BO 2 Products of inertia (kg-m2) Ixy,Ixz,Iyz 12666300 2 Mass (kg) 2 Number of Nodes 69 BO 70 BO 1 298.323 0 0 2 Node ID, Node coord. (meters) x,y,z 71 BO 2 Node ID, Node coord. (meters) x,y,z 2 0 0 0 72 BO 3 0 0 300 2 Node ID, Node coord. (meters) x,y,z 73 BO 4 0 0 -300 2 Node ID, Node coord. (meters) x,y,z 74 BO 2 Node ID, Node coord. (meters) x,y,z 5 500 0 0 75 BO 2 Node ID, Node structual joint ID 76 BO 3 3 Body ID number 77 BO 3 Type (Rigid, Flexible, NASTRAN) 78 BO 3 Number of modes 3 Modal calculation option (0, 1 or 2) 79 BO 80 BO 3 Foreshortening option (Y/N) 81 BO 3 Model reduction method (NO,MS,MC,CC,QM,CV) 82 BO 3 NASTRAN data file FORTRAN unit number (40 - 60) 83 BO 3 Number of augmented nodes (0 if none) 84 BO 3 Damping matrix option (NS,CD,HL,SD) 85 BO 3 Constant damping ratio 86 BO 3 Low frequency, High frequency ratios 87 BO 3 Mode ID number, damping ratio 88 BO 3 Conversion factors: Length, Mass, Force 89 BO 3 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 90 BO 3 Moments of inertia (kg-m2) Ixx, Iyy, Izz 1.7E12 1.7E12 3.4E12 3 Products of inertia (kg-m2) Ixy, Ixz, Iyz 0 0 0 91 BO 3 Products of inertia (kg-m2) Ixy, Ixz, Iyz 92 BO 3 Mass (kg) 3 Number of Nodes 2046600 93 BO 94 BO 1 0 0 0 3 Node ID, Node coord. (meters) x,y,z 95 BO 96 BO 3 Node ID, Node coord. (meters) x,y,z 2 0 0 0 3 Node ID, Node structual joint ID 97 BO 4 4 Body ID number R 4 Type (Rigid, Flexible, NASTRAN)
4 Number of modes 99 BO 100 BO 101 BO 4 Modal calculation option (0, 1 or 2) 102 BO 4 Foreshortening option (Y/N) 4 Model reduction method (NO,MS,MC,CC,QM,CV) 103 BO 4 NASTRAN data file FORTRAN unit number (40 - 60) 104 BO 4 Number of augmented nodes (0 if none) 105 BO 4 Damping matrix option (NS,CD,HL,SD) 4 Constant damping ratio 106 BO 107 BO 108 BO 4 Low frequency, High frequency ratios 109 BO 4 Mode ID number, damping ratio 4 Conversion factors: Length, Mass, Force 110 BO 4 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 111 BO 1.7E12 1.7E12 3.4E12 4 Moments of inertia (kg-m2) Ixx, Iyy, Izz 112 BO 4 Products of inertia (kg-m2) Ixy, Ixz, Iyz 4 Mass (kg) 0 0 0 113 BO 2046600 114 BO 115 BO 4 Number of Nodes 1 0 0 0 116 BO 4 Node ID, Node coord. (meters) x,y,z 2 0 0 0 4 Node ID, Node coord. (meters) x,y,z 117 BO 4 Node ID, Node structual joint ID 118 BO

HINGE

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119 HI 1 Hinge ID number
120 HI 1 Inboard body ID, Outboard body ID
121 HI 1 "p" node ID, "q" node ID

122 HI 1 Number of rotation DOFs, Rotation option (F or G) 3 F

123 HI 1 L1 unit vector in inboard body coord, x,y,z 1 0
124 HI 1 L1 unit vector in outboard body coord. x,y,z
125 HI 1 L2 unit vector in inboard body coord. x,y,z
126 HI 1 L2 unit vector in outboard body coord. x,y,z
12b HI 1 L2 unit vector in outboard body coord. x,y,z

127 HI 1 L3 unit vector in inboard body coord. x,y,z

128 HI 1 L3 unit vector in outboard body coord. x,y,z

129 HI 1 Initial rotation angles (deg)

130 HI 1 Initial rotation rates (deg/sec)

10 0 0
                                                                                                             -90. 0. 180.
131 HI 1 Rotation stiffness (newton-meters/rad)
                                                                                                       0 0 0
132 HI 1 Rotation damping (newton-meters/rad)
133 HI 1 Null torque angles (deg)
134 HI 1 Number of translation DOFs
                                                                                                             0 0 0
135 HI 1 First translation unit vector g1
136 HI 1 Second translation unit vector g2
137 HI 1 Third translation unit vector g3
138 HI 1 Initial translation (meters)
                                                                                                            1 0 0
                                                                                                         0 1 0
                                                                                                             0 0 1
0 0 42163421
130 HI I Initial translation (meters) 0 0 42163421
139 HI 1 Initial translation velocity (meters/sec) 3074.681 0 0
140 HI 1 Translation stiffness (newtons/meters) 0 0 0
141 HI 1 Translation damping (newtons/meter/sec) 0 0 0
 142 HI 1 Null force translations
143 HI 2 Hinge ID number
144 HI 2 Inboard body ID, Outboard body ID
145 HI 2 "p" node ID, "q" node ID
                                                                                                              1 2
                                                                                                             2 2
146 HI 2 Number of rotation DOFs
147 HI 2 L1 unit vector in inboard body coord. x,y,z
148 HI 2 L1 unit vector in outboard body coord. x,y,z
148 HI 2 L1 unit vector in outboard body coord. x,y,z
168 HI 2 Number of rotation DOFs
1 0 0 1
148 HI 2 L1 unit vector in outboard body coord. x,y,z
153 HI 2 Initial rotation angles (deg)
154 HI 2 Initial rotation rates (deg/sec)
                                                                                                               0.00417807
154 nl 2 initial rotation rates (deg/sec)
155 HI 2 Rotation stiffness (newton-meters/rad)
156 HI 2 Rotation damping (newton-meters/rad/sec)
157 HI 2 Null torque angles (deg)
158 HI 2 Number of translation DOFS
                                                                                                              0
159 HI 2 First translation unit vector g1
160 HI 2 Second translation unit vector g2
161 HI 2 Third translation unit vector g3
                                                                                                             1 0 0
                                                                                                            0 1 0
                                                                                                              0 0 1
                                                                                                               0 0 0
 162 HI 2 Initial translation (meters)
 163 HI 2 Initial translation (meters/sec)
164 HI 2 Translation stiffness (newtons/meters)
165 HI 2 Translation damping (newtons/meter/sec)
 166 HI 2 Null force translations
 167 HI 3 Hinge ID number
                                                                                                               1 3
 168 HI 3 Inboard body ID, Outboard body ID
 169 HI 3 "p" node ID, "q" node ID
170 HI 3 Number of rotation DOFs
171 HI 3 L1 unit vector in inboard body coord. x,y,z
                                                                                                               0 0 1
 172 HI 3 L1 unit vector in outboard body coord. x,y,z
                                                                                                               0 0 1
 172 HI 3 L1 unit vector in outboard body coord. x,y,z

173 HI 3 L2 unit vector in inboard body coord. x,y,z

174 HI 3 L2 unit vector in outboard body coord. x,y,z

175 HI 3 L3 unit vector in inboard body coord. x,y,z

0 1 0
 176 HI 3 L3 unit vector in outboard body coord. x,y,z
                                                                                                               180. 0. -135.
 177 HI 3 Initial rotation angles (deg)
178 HI 3 Initial rotation rates (deg/sec)
 179 HI 3 Rotation stiffness (newton-meters/rad)
 180 HI 3 Rotation damping (newton-meters/rad/sec)
181 HI 3 Null torque angles (deg)
 182 HI 3 Number of translation DOFs
                                                                                                        1 0 0
0 1 0
 183 HI 3 First translation unit vector g1
184 HI 3 Second translation unit vector g2
185 HI 3 Third translation unit vector g3
                                                                                                               0 0 1
 186 HI 3 Initial translation (meters)
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Contract No. Bd Systems® NAS8-00151 TCD20000222A Final Report 29 December 2000 3 Initial translation velocity (meters/sec) 3 Translation stiffness (newtons/meters) 189 HI 3 Translation damping (newtons/meter/sec) 190 HI 3 Null force translations 191 HI 4 Hinge ID number 192 HI 4 Inboard body ID, Outboard body ID 193 HI 4 "p" node ID, "q" node ID 1 4 4 2 193 HI 4 Number of rotation DOFs 194 HI 0 0 1 195 HI 4 L1 unit vector in inboard body coord. x,y,z 196 HI 4 L1 unit vector in outboard body coord. x,y,z 0 0 1 4 L2 unit vector in inboard body coord. x,y,z 197 HI 4 L2 unit vector in inboard body coord. x,y,z 198 HI 4 L2 unit vector in outboard body coord. x,y,z 199 HI 4 L3 unit vector in inboard body coord. x,y,z 0 1 0 0 1 0 4 L3 unit vector in outboard body coord. x,y,z 200 HI 180. 0 -45. 4 Initial rotation angles (deg) 201 HI 4 Initial rotation rates (deg/sec) 202 HI 4 Rotation stiffness (newton-meters/rad) 203 HI 204 HI 4 Rotation damping (newton-meters/rad/sec) 205 HI 4 Null torque angles (deg) n 206 HI 4 Number of translation DOFs 1 0 0 207 HI 4 First translation unit vector gl 4 Second translation unit vector g2 4 Third translation unit vector g3 0 1 0 208 HI 0 0 1 209 HI 0 0 0 4 Initial translation (meters) 210 HI 211 HI 4 Initial translation velocity (meters/sec)
212 HI 4 Translation stiffness (newtons/meters)
213 HI 4 Translation damping (newtons/meter/sec) 214 HI 4 Null force translations SENSOR 215 SE 1 Sensor ID number 1 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ET 216 SE 217 SE 1 Mounting point body ID, Mounting point node ID 1 Second mounting point body ID, Second node ID 218 SE 1 Input axis unit vector (IA) x,y,z 219 SE 1 Mounting point Hinge index, Axis index 220 SE 1 First focal plane unit vector (Fp1) x,y,z 0 0 -1 221 SE 1 Second focal plane unit vector (Fp2) x,y,z 1 Sun/Star unit vector (Us) x,y,z 0 1 0 222 SE 223 SE 1 Velocity Aberration Option (Y/N) 224 SE 1 Euler Angle Sequence (1-6) 225 SE 1 CMG ID number and Gimbal number 226 SE 6378000 0 0 4.178074D-3 1 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 227 SE 2 Sensor ID number 228 SE 229 SE 2 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST 230 SE 2 Mounting point body ID, Mounting point node ID 231 SE 2 Second mounting point body ID, Second node ID 2 Input axis unit vector (IA) x,y,z 232 SE 233 SE 2 Mounting point Hinge index, Axis index 234 SE 2 First focal plane unit vector (Fp1) x,y,z 0 -1 0 1 0 0 2 Second focal plane unit vector (Fp2) x,y,z 235 SE 236 SE 2 Sun/Star unit vector (Us) x,y,z 0 1 0 N 237 SE 2 Velocity Aberration Option (Y/N) 2 Euler Angle Sequence (1-6) 238 SE 2 CMG ID number and Gimbal number 239 SE 240 SE 2 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 3 Sensor ID number 241 SE 3 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST 242 SE 243 SE 3 Mounting point body ID, Mounting point node ID 3 Second mounting point body ID, Second node ID 244 SE 3 Input axis unit vector (IA) x,y,z 245 SE 3 Mounting point Hinge index, Axis index 246 SE 3 First focal plane unit vector (Fp1) x,y,z -1 0 0 247 SE 0 0 1 3 Second focal plane unit vector (Fp2) x,y,z 248 SE 0 0 0 3 Sun/Star unit vector (Us) x,y,z 249 SE Ν 3 Velocity Aberration Option (Y/N) 250 SE

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251 SE 3 Eule
252 SE 3 CMG
253 SE 3 Eart
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3 Euler Angle Sequence (1-6)
        3 CMG ID number and Gimbal number
253 SE 3 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
        4 Sensor ID number
254 SE
        4 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) A3
255 SE
256 SE 4 Mounting point body ID, Mounting point node ID
257 SE 4 Second mounting point body ID, Second node ID
        4 Input axis unit vector (IA) x,y,z
258 SE
        4 Mounting point Hinge index, Axis index
259 SE
        4 First focal plane unit vector (Fp1) x,y,z
        4 Second focal plane unit vector (Fp2) x,y,z
261 SE
        4 Sun/Star unit vector (Us) x,y,z
262 SE
        4 Velocity Aberration Option (Y/N)
263 SE
        4 Euler Angle Sequence (1-6)
264 SE
        4 CMG ID number and Gimbal number
265 SE
        4 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
266 SE
        5 Sensor ID number
267 SE
         5 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) LV
268 SE
         5 Mounting point body ID, Mounting point node ID
269 SE
        5 Second mounting point body ID, Second node ID
270 SE
         5 Input axis unit vector (IA) x,y,z
271 SE
         5 Mounting point Hinge index, Axis index
272 SE
         5 First focal plane unit vector (Fp1) x,y,z
273 SE
         5 Second focal plane unit vector (Fp2) x,y,z
274 SE
         5 Sun/Star unit vector (Us) x,y,z
275 SE
        5 Velocity Aberration Option (Y/N)
276 SE
        5 Euler Angle Sequence (1-6)
277 SE
        5 CMG ID number and Gimbal number
5 Earth pt (rad,lat,lon,rotation [m/e, d, d, d/s])
278 SE
279 SE
        6 Sensor ID number
280 SE
        6 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV L
281 SE
        6 Mounting point body ID, Mounting point node ID
282 SE
        6 Second mounting point body ID, Second node ID
283 SE
                                                               1 0 0
        6 Input axis unit vector (IA) x,y,z
284 SE
         6 Mounting point Hinge index, Axis index
285 SE
        6 First focal plane unit vector (Fp1) x,y,z
286 SE
        6 Second focal plane unit vector (Fp2) x,y,z
287 SE
        6 Sun/Star unit vector (Us) x,y,z
6 Velocity Aberration Option (Y/N)
288 SE
289 SE
        6 Euler Angle Sequence (1-6)
290 SE
291 SE 6 CMG ID number and Gimbal number
        6 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
292 SE
        7 Sensor ID number
         7 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV L
294 SE
        7 Mounting point body ID, Mounting point node ID
295 SE
        7 Second mounting point body ID, Second node ID
                                                               1 0 0
        7 Input axis unit vector (IA) x,y,z
297 SE
         7 Mounting point Hinge index, Axis index
298 SE
        7 First focal plane unit vector (Fp1) x,y,z
299 SE
        7 Second focal plane unit vector (Fp2) x,y,z
300 SE
         7 Sun/Star unit vector (Us) x,y,z
301 SE
        7 Velocity Aberration Option (Y/N)
302 SE
        7 Euler Angle Sequence (1-6)
303 SE
         7 CMG ID number and Gimbal number
304 SE
         7 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
305 SE
           ACTR
         1 Actuator ID number
         1 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7)
                                                               MO
 307 AC
          1 Actuator location; Node or Hinge (N or H)
 308 AC
         1 Mounting point body ID number, node ID number
                                                               2 2
309 AC
         1 Second mounting point body ID, second node ID
310 AC
                                                               0 1 0
         1 Output axis unit vector x,y,z
 311 AC
         1 Mounting point Hinge index, Axis index
 312 AC
          1 Rotor spin axis unit vector x,y,z
 313 AC
```

Bd Systems® TCD20000222A 29 December 2000 1 Initial rotor momentum, H 314 AC 1 Outer gimbal- angle(deg), inertia, friction(D,S,B,N) 1 Outer gimbal axis unit vector x,y,z 1 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 317 AC 1 Inner gimbal- angle(deg), inertia, friction(D,S,B,N) 318 AC 1 Inner gimbal axis unit vector x,y,z 319 AC 1 In gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 320 AC 1 Initial length and rate, y(to) and ydot(to) 321 AC 1 Constants; K1 or wo, n or zeta, Kg, Jm 322 AC 1 Non-linearities; TLim, Tco, Dz 323 AC 2 2 Actuator ID number 324 AC 2 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) MO 325 AC 2 Actuator location; Node or Hinge (N or H) 326 AC 2 2 2 Mounting point body ID number, node ID number 327 AC 2 Second mounting point body ID, second node ID 328 AC 0 0 1 2 Output axis unit vector x,y,z 329 AC 2 Mounting point Hinge index, Axis index 330 AC 2 Rotor spin axis unit vector x,y,z 331 AC 2 Initial rotor momentum, H 332 AC 2 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 333 AC 2 Outer gimbal axis unit vector x,y,z 334 AC 2 Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k)335 AC 2 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 336 AC 2 Inner gimbal axis unit vector x,y,z 337 AC 2 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 338 AC 2 Initial length and rate, y(to) and ydot(to) 339 AC 2 Constants; K1 or wo, n or zeta, Kg, Jm 340 AC 2 Non-linearities; TLim, Tco, Dz 341 AC 3 Actuator ID number 342 AC 3 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) MO 343 AC 3 Actuator location; Node or Hinge (N or H) 344 AC 3 Mounting point body ID number, node ID number 2 2 345 AC 3 Second mounting point body ID, second node ID 346 AC 1 0 0 3 Output axis unit vector x,y,z 347 AC 3 Mounting point Hinge index, Axis index 348 AC 3 Rotor spin axis unit vector x,y,z 349 AC 3 Initial rotor momentum, H 350 AC 3 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 351 AC 3 Outer gimbal axis unit vector x,y,z 352 AC 3 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 353 AC 3 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 354 AC 3 Inner gimbal axis unit vector x, y, z355 AC 3 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 356 AC 3 Initial length and rate, y(to) and ydot(to) 357 AC 3 Constants; K1 or wo, n or zeta, Kg, Jm 358 AC 3 Non-linearities; TLim, Tco, Dz 359 AC 4 4 Actuator ID number 360 AC Т 4 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 361 AC 4 Actuator location; Node or Hinge (N or H) 362 AC 4 Mounting point body ID number, node ID number 4 Second mounting point body ID, second node ID 363 AC 364 AC 4 Output axis unit vector x,y,z 365 AC 2 1 4 Mounting point Hinge index, Axis index 366 AC 4 Rotor spin axis unit vector x,y,z 367 AC 4 Initial rotor momentum, H 368 AC 4 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 369 AC 4 Outer gimbal axis unit vector x,y,z 370 AC 4 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 371 AC 4 Inner gimbal- angle(deg), inertia, friction(D,S,B,N) 372 AC 4 Inner gimbal axis unit vector x,y,z 373 AC 4 In gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 374 AC 4 Initial length and rate, y(to) and ydot(to) 375 AC 4 Constants; K1 or wo, n or zeta, Kg, Jm 376 AC 4 Non-linearities; TLim, Tco, Dz 377 AC 5 Actuator ID number 378 AC 5 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) J 379 AC

380 AC

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10D2 29 De				
381		5	Mounting point body ID number, node ID number	2 5
382		5	Second mounting point body ID, second node ID	
383		5	Output axis unit vector x,y,z	-1 0 0
384		5	Mounting point Hinge index, Axis index	
385	AC	5	Rotor spin axis unit vector x,y,z	
386	AC	5	Initial rotor momentum, H	
387		5	Outer gimbal- angle(deg), inertia, friction(D, S, B, N)	
388		5	Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)	
389		5	Inner gimbal- angle(deg), inertia, friction(D, S, B, N)	
390		5	Inner gimbal axis unit vector x,y,z	
391 392		5	In gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k)	
393		5	Initial length and rate, y(to) and ydot(to)	
394		5	Constants; K1 or wo, n or zeta, Kg, Jm	
395		5	Non-linearities; TLim, Tco, Dz	
			CONTROLLER	
206	CO	1	Controller ID number	1
396 397		1	Controller type (CB,CM,DB,DM,UC,UD)	CM
398		1	Sample time (sec)	
399		1	Number of inputs, Number of outputs	4 4
	CO	1	Number of states	
401	CO	1	Output No., Input type (I,S,T), Input ID, Gain	
			TAMED COMMECT	
			INTERCONNECT	
402	IN	1	Interconnect ID number	1
	IN	1	Source type(S.C. or F), Source ID, Source row #	S 1 1
404	IN	1	Destination type(A or C), Dest ID, Dest row #	C 1 1 4.41E13
405	IN	1	Gain	4.41613
		_	- I I number	2
	IN	2	<pre>Interconnect ID number Source type(S,C, or F),Source ID,Source row #</pre>	C 1 1
	IN	2	Destination type(A or C), Dest ID, Dest row #	A 1 1
	IN		Gain	1
407	114	-		
410	IN	3	Interconnect ID number	3
411	IN	3	Source type(S,C, or F), Source ID, Source row #	S 1 2 C 1 2
	IN		Destination type(A or C), Dest ID, Dest row #	1.67E12
413	IN	3	Gain	
414	IN	Δ	Interconnect ID number	4
	IN	Δ	Source type(S.C. or F), Source ID, Source row #	C 1 2
	IN	4	Destination type(A or C), Dest ID, Dest row #	A 2 1
417	IN		Gain	1
			. The sumban	5
	IN	5	Interconnect ID number Source type(S,C, or F),Source ID,Source row #	s 2 1
	IN IN	5	Destination type(A or C), Dest ID, Dest row #	C 1 3
	IN IN		Gain	4.31E13
422	2 IN	6	Interconnect ID number	6 C 1 3
423	IN	6	Source type(S,C, or F), Source ID, Source row #	A 3 1
	IN		Destination type(A or C), Dest ID, Dest row #	1
425	IN	6	Gain	_
426	5 IN	7	Interconnect ID number	7
	7 IN	7	Source type(S.C. or F),Source ID,Source row #	S 3 1
	BIN	7	Destination type(A or C), Dest ID, Dest row #	C 1 4
) IN		'Gain	6.7E8
	_		TD number	8
) IN	8	Interconnect ID number Source type(S,C, or F),Source ID,Source row #	C 1 4
	LIN	3	B Destination type(A or C), Dest ID, Dest row #	A 4 1
	IN S		Gain	1
40.	, ±1A		, un	_
434	4 IN	9	Interconnect ID number	9
	5 IN	ç	Source type(S,C, or F),Source ID,Source row #	S 3 3

436 IN 9 Destination type(A or C), Dest ID, Dest row # A 5 1 437 IN 9 Gain 7

isc3_flex_winsol.int (Concept 1) Winter Solstice

TREETOPS REV 10P2 4/10/00

SIM CONTROL

	~~	0 m: 61 a	ISC MODEL,	THIRD VERSION
_	SI	0 Title	100000	
2	SI	O Simulation stop time		
3	SI	0 Plot data interval	20	
4	SI	0 Integration type (R,S,U, OR V)	R	
5	SI	0 Step size (sec)	.1	
6	SI	O Sandia ODE solver absolute and relative error		
_	SI	O RK78 ODE solver absolute error and first step size		
	SI	O Linearization option (L,Z or N)	N	
_			N	
9	SI	U Medicale operon	Y	
10	SI	0 Contact force computation option (Y/N)	-	
11	SI	O Constraint force computation option (Y/N)	N	
12	SI	O Small angle speedup option (All, Bypass, First, Nth)	A	
	SI	0 Mass matrix speedup option (All, Bypass, First, Nth)	A	
		0 Non-Linear speedup option (All, Bypass, First, Nth)	A	
14	SI	O Non-Linear speedup option (All Proper River Mth)	Α	
15	SI	O Constraint speedup option (All, Bypass, First, Nth)		
16	SI	O Constraint stabilization option (Y/N)	N	
17	SI	O Stabilization epsilon		

GENGRAV

18 GG 19 GG	0 Gravity, earth sphere/nonsphere/user (S/N/U)? 1 Input gravity constants: GME, ERAD, EMASS	N
20 GG	1 Spherical or Nonspherical (S/N)?	
21 GG	1 Gravity Potential Harmonics J2, J3, J4	M
22 GG	0 English (ft-slug-s) or metric (m-kg-s) (E/M)?	M 20 12 2020
23 GG	O Day, Month, Year,	
24 GG	0 GMT @ sim time 0 (minutes past midnight,	360 Y
25 GG	O Solar Pressure forces Y/N?	=
26 GG	0 Input new data for aero model? (Y/N)	N
27 GG	1 Solar flux F10 for aero model	
28 GG	1 Solar flux, 81 day average F10B	
29 GG	1 Geomagnetic index, GEAP	

BODY

2.0	TO	1	Body ID number	1	
	во	1	body in identification NACODANI)	F	
31	BO		Type (Rigid, Flexible, NASTRAN)	24	
32	BO		Number of modes		
33	во		Modal calculation option (0, 1 or 2)	2	
34	BO	1	Foreshortening option (Y/N)		
35	BO	1	Model reduction method (NO, MS, MC, CC, QM, CV)		
36	BO	1	NASTRAN data file FORTRAN unit number (40 - 60)		
	во	1	Number of augmented nodes (0 if none)		
38	BO	1	Damping matrix option (NS,CD,HL,SD)		
39	во	1	Constant damping ratio		
40	во	1	Low frequency, High frequency ratios		
41	во	1	Mode ID number, damping ratio		
42	BO	1	Conversion factors: Length, Mass, Force	1	
43	BO	1	Inertia reference node (0=Bdy Ref Frm; 1=mass cen)	6.2852173E11	6 2852173F11
44	BO	1	Moments of inertia (kg-m2) Ixx, Iyy, Izz	0.20321/3611	0.2002173611
6.7057352E8					
45	во	1	Products of inertia (kg-m2) Ixy, Ixz, Iyz	0 0 0	
46	BO	1	Mass (kg)	1.6168633E5	
47	во	1	Number of Nodes	4	

Contract No. Bd Systems® NAS8-00151 TCD20000222A Final Report 29 December 2000 48 BO 1 Node ID, Node coord. (meters) x,y,z 49 BO 1 Node ID, Node coord. (meters) x,y,z 1 0 0 0 1 Node ID, Node coord. (meters) x,y,z 1 Node ID, Node coord. (meters) x,y,z 2 0 0 0 3 0 0 3188.8 50 BO 1 Node ID, Node coord. (meters) x,y,z
51 BO 1 Node ID, Node coord. (meters) x,y,z
52 BO 1 Node ID, Node coord. (meters) x,y,z
52 BO 1 Node ID, Node structual joint ID 4 0 0 -3188.8 2 53 BO 2 Body ID number R 2 Type (Rigid, Flexible, NASTRAN) 54 BO 55 BO 2 Number of modes 56 BO 2 Modal calculation option (0, 1 or 2) 57 BO 2 Foreshortening option (Y/N)2 Model reduction method (NO, MS, MC, CC, QM, CV) 58 BO 2 Model reduction method (NO,MS,MC,CC,QM,CV) 59 BO 2 NASTRAN data file FORTRAN unit number (40 - 60) 60 BO 2 Number of augmented nodes (0 if none) 61 BO 2 Damping matrix option (NS,CD,HL,SD) 2 Constant damping ratio 62 BO 63 BO 2 Low frequency, High frequency ratios 64 BO 2 Mode ID number, damping ratio 65 BO 2 Conversion factors: Length, Mass, Force 66 BO 2 Inertia reference node (0=Bdy Ref Frm 2 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 .8543E12 1.5601E12 67 BO 2 Moments of inertia (kg-m2) Ixx, Iyy, Izz 1.3822E12 68 BO 2 Products of inertia (kg-m2) Ixy, Ixz, Iyz 69 BO 2 Mass (kg) 0 0 0 12666300 70 BO 2 Number of Nodes 1 298.323 0 0 71 BO 2 Node ID, Node coord. (meters) x,y,z 2 0 0 0 2 Node ID, Node coord. (meters) x,y,z 3 0 0 300 72 BO 2 Node ID, Node coord. (meters) x,y,z 73 BO 2 Node ID, Node coord. (meters) x,y,z 2 Node ID, Node coord. (meters) x,y,z 2 Node ID, Node structual joint ID 4 0 0 -300 74 BO 5 500 0 0 75 BO 76 BO 3 Body ID number 77 BO 3 Type (Rigid, Flexible, NASTRAN) 3 Number of modes R 78 BO 79 BO 3 Modal calculation option (0, 1 or 2) 3 Foreshortening option (Y/N) 81 BO 3 Model reduction method (NO, MS, MC, CC, QM, CV) 82 BO 3 NASTRAN data file FORTRAN unit number (40 - 60) 83 BO 3 Number of augmented nodes (0 if none) 84 BO 3 Damping matrix option (NS,CD,HL,SD) 3 Constant damping ratio 85 BO 86 BO 3 Low frequency, High frequency ratios 87 BO 3 Mode ID number, damping ratio 88 BO 3 Conversion factors: Length, Mass, Force 89 BO 3 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 90 BO 1.7E12 1.7E12 3.4E12 3 Moments of inertia (kg-m2) Ixx, Iyy, Izz 91 BO 3 Products of inertia (kg-m2) Ixy,Ixz,Iyz 0 0 0 92 BO 2046600 3 Mass (kg) 93 BO 2 3 Number of Nodes 94 BO 1 0 0 0 3 Node ID, Node coord. (meters) x,y,z 95 BO 2 0 0 0 3 Node ID, Node coord. (meters) x,y,z 96 BO 3 Node ID, Node structual joint ID 97 BO 4 98 BO 4 Body ID number 4 Type (Rigid, Flexible, NASTRAN) 99 BO 100 BO 4 Number of modes 4 Modal calculation option (0, 1 or 2) 101 BO 4 Foreshortening option (Y/N) 102 BO 4 Model reduction method (NO,MS,MC,CC,QM,CV) 103 BO 4 NASTRAN data file FORTRAN unit number (40 - 60) 104 BO 4 Number of augmented nodes (0 if none) 105 BO 4 Damping matrix option (NS,CD,HL,SD) 106 BO 4 Constant damping ratio 107 BO 4 Low frequency, High frequency ratios 108 BO 4 Mode ID number, damping ratio 109 BO 4 Conversion factors: Length, Mass, Force 110 BO 4 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 111 BO 4 Moments of inertia (kg-m2) Ixx, Iyy, Izz 1.7E12 1.7E12 3.4E12 112 BO 0 0 0 4 Products of inertia (kg-m2) Ixy, Ixz, Iyz 113 BO 2046600 114 BO 4 Mass (kg)

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176 HI 3 L3 unit vector in outboard body coord. x,y,z

3 Initial rotation angles (deg) 3 Initial rotation rates (deg/sec)

179 HI 3 Rotation stiffness (newton-meters/rad)

177 HI 178 HI Bd Systems® NAS8-00151 TCD20000222A Final Report 29 December 2000 180 HI 3 Rotation damping (newton-meters/rad/sec) 3 Null torque angles (deg) 182 HI 3 Number of translation DOFs 183 HI 3 First translation unit vector gl 1 0 0 0 1 0 184 HI 3 Second translation unit vector g2 185 HI 3 Third translation unit vector g3 0 0 1 0 0 0 186 HI 3 Initial translation (meters) 187 HI 3 Initial translation velocity (meters/sec) 3 Translation stiffness (newtons/meters) 188 HI 189 HI 3 Translation damping (newtons/meter/sec) 190 HI 3 Null force translations 4 Hinge ID number 191 HI 1 4 192 HI 4 Inboard body ID, Outboard body ID 4 2 193 HI 4 "p" node ID, "q" node ID 194 HI 4 Number of rotation DOFs 195 HI 4 L1 unit vector in inboard body coord. x,y,z 0 0 0 1 196 HI 4 L1 unit vector in outboard body coord. x,y,z 0 0 1 197 HI 4 L2 unit vector in inboard body coord. x,y,z 198 HI 4 L2 unit vector in outboard body coord. x,y,z 199 HI 4 L3 unit vector in inboard body coord. x,y,z 0 1 0 200 HI $\,$ 4 L3 unit vector in outboard body coord. x,y,z0 1 0 -90. 0. -56.75 201 HI 4 Initial rotation angles (deg) 202 HI 4 Initial rotation rates (deg/se 4 Initial rotation rates (deg/sec) 203 HI 4 Rotation stiffness (newton-meters/rad) 204 HI 4 Rotation damping (newton-meters/rad/sec) 205 HI 4 Null torque angles (deg) 206 HI 4 Number of translation DOFs 1 0 0 207 HI 4 First translation unit vector gl 208 HI 4 Second translation unit vector g2 0 1 0 0 0 1 4 Third translation unit vector g3 209 HI 4 Third translation unit vector 210 HI 4 Initial translation (meters) $0 \ 0 \ 0$ 211 HI 4 Initial translation velocity (meters/sec) 212 HI 4 Translation stiffness (newtons/meters)
213 HI 4 Translation damping (newtons/meter/sec) 214 HI 4 Null force translations SENSOR 1 Sensor ID number 1 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ET 215 SE 1 Mounting point body ID, Mounting point node ID 217 SE 1 Second mounting point body ID, Second node ID 1 Input axis unit vector (IA) x,y,z 219 SE 1 Mounting point Hinge index, Axis index 220 SE 1 First focal plane unit vector (Fp1) x,y,z 1 Second focal plane unit vector (Fp2) x,y,z 1 Sun/Star unit vector (Us) x,y,z 0 0 -1 221 SE 0 1 0 222 SE 223 SE 1 Velocity Aberration Option (Y/N) 224 SE 1 Euler Angle Sequence (1-6) 225 SE 1 CMG ID number and Gimbal number 226 SE 6378000 0 0 4.178074D-3 1 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 227 SE 228 SE 2 Sensor ID number 2
229 SE 2 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST 230 SE 2 Mounting point body ID, Mounting point node ID 2 2 2 Second mounting point body ID, Second node ID 231 SE 2 Input axis unit vector (IA) x,y,z 232 SE 2 Mounting point Hinge index, Axis index 233 SE 2 First focal plane unit vector (Fp1) x,y,z 2 Second focal plane unit vector (Fp2) x,y,z 2 Sun/Star unit vector (Us) x,y,z 0 -1 0 1 0 0 235 SE 0 1 0 236 SE N 2 Velocity Aberration Option (Y/N) 237 SE 2 Euler Angle Sequence (1-6) 238 SE 2 CMG ID number and Gimbal number 239 SE 240 SE 2 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 3 Sensor ID number 241 SE 3 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST 242 SE 3 Mounting point body ID, Mounting point node ID 243 SE

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3 Second mounting point body ID, Second node ID
244 SE
        3 Input axis unit vector (IA) x,y,z
       3 Mounting point Hinge index, Axis index
                                                             -1 0 0
        3 First focal plane unit vector (Fp1) x,y,z
247 SE
                                                             0 0 1
        3 Second focal plane unit vector (Fp2) x,y,z
248 SE
                                                             0 0 0
        3 Sun/Star unit vector (Us) x,y,z
249 SE
        3 Velocity Aberration Option (Y/N)
250 SE
        3 Euler Angle Sequence (1-6)
251 SE
        3 CMG ID number and Gimbal number
252 SE
        3 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
253 SE
        4 Sensor ID number
254 SE
        4 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) A3
255 SE
        4 Mounting point body ID, Mounting point node ID
        4 Second mounting point body ID, Second node ID
257 SE
        4 Input axis unit vector (IA) x,y,z
258 SE
        4 Mounting point Hinge index, Axis index
259 SE
        4 First focal plane unit vector (Fp1) x,y,z
260 SE
        4 Second focal plane unit vector (Fp2) x,y,z
261 SE
        4 Sun/Star unit vector (Us) x,y,z
262 SE
        4 Velocity Aberration Option (Y/N)
263 SE
        4 Euler Angle Sequence (1-6)
264 SE
        4 CMG ID number and Gimbal number
265 SE
        4 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
266 SE
267 SE
        5 Sensor ID number
        5 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) LV
268 SE
         5 Mounting point body ID, Mounting point node ID
269 SE
        5 Second mounting point body ID, Second node ID
270 SE
         5 Input axis unit vector (IA) x,y,z
271 SE
         5 Mounting point Hinge index, Axis index
272 SE
        5 First focal plane unit vector (Fp1) x,y,z
273 SE
        5 Second focal plane unit vector (Fp2) x,y,z
274 SE
        5 Sun/Star unit vector (Us) x,y,z
275 SE
        5 Velocity Aberration Option (Y/N)
276 SE
        5 Euler Angle Sequence (1-6)
277 SE
        5 CMG ID number and Gimbal number
278 SE
        5 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
279 SE
        6 Sensor ID number
280 SE
        6 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV L
281 SE
        6 Mounting point body ID, Mounting point node ID
282 SE
        6 Second mounting point body ID, Second node ID
                                                              1 0 0
        6 Input axis unit vector (IA) x,y,z
284 SE
        6 Mounting point Hinge index, Axis index
285 SE
        6 First focal plane unit vector (Fp1) x,y,z
286 SE
        6 Second focal plane unit vector (Fp2) x,y,z
287 SE
        6 Sun/Star unit vector (Us) x,y,z
288 SE
        6 Velocity Aberration Option (Y/N)
289 SE
        6 Euler Angle Sequence (1-6)
        6 CMG ID number and Gimbal number
6 Earth pt (rad,lat,lon,rotation [m/e, d, d, d/s])
291 SE
292 SE
        7 Sensor ID number
293 SE
         7 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV L
        7 Mounting point body ID, Mounting point node ID
295 SE
        7 Second mounting point body ID, Second node ID
                                                              1 0 0
         7 Input axis unit vector (IA) x,y,z
297 SE
         7 Mounting point Hinge index, Axis index
298 SE
        7 First focal plane unit vector (Fp1) x,y,z
299 SE
        7 Second focal plane unit vector (Fp2) x,y,z
300 SE
         7 Sun/Star unit vector (Us) x,y,z
301 SE
        7 Velocity Aberration Option (Y/N)
302 SE
        7 Euler Angle Sequence (1-6)
303 SE
         7 CMG ID number and Gimbal number
304 SE
         7 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
305 SE
           ACTR
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306 AC 1 Actuator ID number

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47 D	29 December 2000							
307		1	Type (J.H.MO, T.B, MA, SG, DG, W, L, M1-M7)	MO				
308	AC	1	Actuator location: Node or Hinge (N or H)	2 2				
309		1	Mounting point body ID number, node ID number	2 4				
310		1	Second mounting point body ID, second node ID Output axis unit vector x,y,z	0 1 0				
311		1	Mounting point Hinge index, Axis index					
312 313		1	Rotor spin axis unit vector x,y,z					
314		1	Initial rotor momentum, H					
315		1	Outer gimbal- angle(deg), inertia, friction(D, S, B, N)					
316	AC	1	Outer gimbal axis unit vector X,Y,Z					
317		1	Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k)					
318		1	<pre>Inner gimbal- angle(deg),inertia,friction(D,S,B,N) Inner gimbal axis unit vector x,y,z</pre>					
319		1	In gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k)					
320 321		1	Initial length and rate, y(to) and ydot(to)					
322		1	Constants; K1 or wo, n or zeta, Kg, Jm					
323	AC	1	Non-linearities; TLim, Tco, Dz					
224		2	Actuator ID number	2				
324 325		2	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7)	MO				
326		2	Actuator location: Node or Hinge (N or H)					
327		2	Mounting point body ID number, node ID number	2 2				
328		2	Second mounting point body ID, second node ID	0 0 1				
	AC	2	Output axis unit vector x,y,z	0 0 1				
330		2	Mounting point Hinge index, Axis index					
331		2	Rotor spin axis unit vector x,y,z Initial rotor momentum, H					
	AC AC	2	Outer gimbal- angle(deg), inertia, friction(D,S,B,N)					
	AC	2	Outer gimbal axis unit vector X,Y,Z					
	AC	2	Out gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kt)/(m, M, B, K)					
336	AC	2	<pre>Inner gimbal- angle(deg), inertia, friction(D,S,B,N)</pre>					
	AC	2	Inner gimbal axis unit vector x,y,z					
	AC	2	<pre>In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to)</pre>					
	AC AC	2	Constants; K1 or wo, n or zeta, Kg, Jm					
	AC	2	Non-linearities; TLim, Tco, Dz					
		-	The number	3				
	AC	3	Actuator ID number	3 MO				
343	AC	3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H)	MO				
343 344	AC AC	3 3 3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number					
343 344 345	AC	3 3 3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID	MO 2 2				
343 344 345 346	AC AC AC	3 3 3 3	Type (J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z	MO				
343 344 345 346 347 348	AC AC AC AC AC AC	3 3 3 3 3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index	MO 2 2				
343 344 345 346 347 348 349	AC AC AC AC AC AC	3 3 3 3 3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z	MO 2 2				
343 344 345 346 347 348 349 350	AC AC AC AC AC AC AC AC	3 3 3 3 3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H	MO 2 2				
343 344 345 346 347 348 349 350 351	AC AC AC AC AC AC AC AC	3 3 3 3 3 3 3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal axis unit vector x,y,z	MO 2 2				
343 344 345 346 347 348 350 351 352	AC AC AC AC AC AC AC AC	3 3 3 3 3 3 3 3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)	MO 2 2				
343 344 345 346 347 348 349 350 351 352 353	AC	3 3 3 3 3 3 3 3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N)	MO 2 2				
343 344 345 346 347 348 350 351 352 353 354 355	AC A	3 3 3 3 3 3 3 3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N)	MO 2 2				
343 344 345 346 347 348 350 351 352 353 354 355	AC A	3 3 3 3 3 3 3 3 3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)	MO 2 2				
343 344 345 347 348 350 351 352 353 354 355	AC A	33 33 33 33 33 33 33 33 33	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to)	MO 2 2				
343 344 345 346 347 348 350 351 352 353 354 355 356	AC A	33 33 33 33 33 33 33 33 33	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)	MO 2 2				
343 344 345 346 347 348 350 351 352 353 354 355 356 357	AC A	3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz	MO 2 2 1 0 0				
343 344 345 346 347 348 349 350 351 352 353 355 357 358 359	AC A	3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz	MO 2 2				
343 344 345 346 347 348 350 351 352 353 354 355 356 357 360 361	AC A	3 3 3 3 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg),inertia,friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg),inertia,friction(D,S,B,N) Inner gimbal- axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H)	MO 2 2 1 0 0				
343 344 345 346 347 348 349 350 351 352 353 354 357 358 357 368 361 362	AC A	3 3 3 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number	MO 2 2 1 0 0				
343 344 345 346 347 348 350 351 352 353 354 355 356 357 366 361 362 363 363	AC A	33 33 33 33 33 33 33 33 33 33 34 44 44 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID	MO 2 2 1 0 0				
343 344 345 346 347 348 350 351 352 353 354 357 360 361 362 363 363 364 365	AC A	33 33 33 33 33 33 33 33 34 44 44 44 44 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID	MO 2 2 1 0 0 0 4 T				
343 344 345 346 347 348 350 351 352 353 354 355 356 361 362 363 363 363 363 363 366 366 366 366	AC A	33 33 33 33 33 33 33 33 34 44 44 44 44 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index	MO 2 2 1 0 0				
343 344 345 346 347 348 350 351 352 353 354 355 357 360 361 362 363 363 363 363 363 363 363 363 363	AC A	33 33 33 33 33 33 33 33 33 34 44 44 44 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z	MO 2 2 1 0 0 0 4 T				
343 344 345 346 347 348 352 353 354 355 356 361 362 363 364 365 366 366 366 366 366 366 366 366 366	AC A	33 33 33 33 33 33 33 33 34 44 44 44 44 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N)	MO 2 2 1 0 0 0 4 T				
343 344 345 346 347 348 350 351 352 353 354 357 358 363 363 364 365 366 366 366 366 366 366 366 366 366	AC A	33 33 33 33 33 33 33 33 34 44 44 44 44 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal- axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N)	MO 2 2 1 0 0 0 4 T				
343 344 345 346 347 348 349 350 351 352 353 354 355 366 367 368 368 368 368 368 368 368 368 368 368	AC A	33 33 33 33 33 33 33 33 33 34 44 44 44 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal- angle(deg), inertia, friction(D,S,B,N)	MO 2 2 1 0 0 0 4 T				
343 344 345 346 347 348 350 351 352 353 354 355 356 361 362 363 363 363 363 363 363 363 373 372 372 372	AC A	33 33 33 33 33 33 33 33 33 34 44 44 44 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal- angle(deg), inertia, friction(D,S,B,N)	MO 2 2 1 0 0 0 4 T				
343 344 345 346 347 348 350 351 352 353 354 355 356 361 362 363 363 363 363 373 372 373	AC A	33 33 33 33 33 33 33 33 34 44 44 44 44 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal- angle(deg), inertia, friction(D,S,B,N)	MO 2 2 1 0 0 0 4 T				

Bd Systems® TCD20000222A 29 December 2000 375 AC 4 Initial length and rate, y(to) and ydot(to) 376 AC 4 Constants; K1 or wo, n or zeta, Kg, Jm 377 AC 4 Non-linearities; TLim, Tco, Dz 5 378 AC 5 Actuator ID number 379 AC 5 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) J 375 L 380 AC 5 Actuator location; Node or Hinge (N or H) 2 5 5 Mounting point body ID number, node ID number 382 AC 5 Second mounting point body ID, second node ID -1 0 0 383 AC 5 Output axis unit vector x,y,z 384 AC 5 Mounting point Hinge index, Axis index 385 AC 5 Rotor spin axis unit vector x,y,z 386 AC 5 Initial rotor momentum, H 387 AC 5 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 388 AC 389 AC 5 Outer gimbal axis unit vector x,y,z 5 Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 390 AC 5 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 5 Inner gimbal axis unit vector x,y,z 391 AC 5 In gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 392 AC 393 AC 5 Initial length and rate, y(to) and ydot(to) 394 AC 5 Constants; K1 or wo, n or zeta, Kg, Jm 395 AC 5 Non-linearities; TLim, Tco, Dz CONTROLLER 396 CO 1 Controller ID number CM 397 CO 1 Controller type (CB,CM,DB,DM,UC,UD) 398 CO 1 Sample time (sec) 4 4 1 Number of inputs, Number of outputs 399 CO 400 CO 1 Number of states 401 CO 1 Output No., Input type (I,S,T), Input ID, Gain INTERCONNECT 1 Interconnect ID number 402 IN s 1 1 403 IN 1 Source type(S,C, or F), Source ID, Source row # 1 Destination type(A or C),Dest ID,Dest row # C 1 1 404 IN 4.41E13 1 Gain 405 IN 2 Interconnect ID number 406 IN C 1 1 2 Source type(S,C, or F), Source ID, Source row # 407 IN 2 Destination type(A or C),Dest ID,Dest row # A 1 1 408 IN 409 IN 2 Gain 3 Interconnect ID number 410 IN 3 Source type(S,C, or F),Source ID,Source row # S 1 2 411 IN C 1 2 3 Destination type(A or C),Dest ID,Dest row # 412 IN 1.67E12 3 Gain 413 IN 4 Interconnect ID number 414 TN 4 Source type(S,C, or F), Source ID, Source row # C 1 2 415 IN A 2 1 416 IN 4 Destination type(A or C), Dest ID, Dest row # 1 4 Gain 417 IN 5 Interconnect ID number 418 IN 5 Source type(S,C, or F),Source ID,Source row # S 2 1 419 IN C 1 3 5 Destination type(A or C), Dest ID, Dest row # 420 IN 4.31E13 421 IN 5 Gain 6 Interconnect ID number 422 IN 6 Source type(S,C, or F), Source ID, Source row # C 1 3 423 IN A 3 1 6 Destination type(A or C), Dest ID, Dest row # 424 IN 425 IN 7 Interconnect ID number 426 IN S 3 1 7 Source type(S,C, or F), Source ID, Source row

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7 Destination type(A or C), Dest ID, Dest row #

C 1 4

6.7E8

427 TN

428 TN

429 IN 7 Gain

Bd Systems® TCD20000222A 29 December 2000 430 IN 8 Interconnect ID number 431 IN 8 Source type(S,C, or F),Source ID,Source row # 432 IN 8 Destination type(A or C),Dest ID,Dest row # C 1 4 A 4 1 1 8 Gain 433 IN 9 Interconnect ID number 434 IN 435 IN 9 Source type(S,C, or F), Source ID, Source row # s 3 3 436 IN 9 Destination type(A or C), Dest ID, Dest row # 437 IN 9 Gain A 5 1

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A.2 Concept 2A Definitions and TREETOPS files

Sensor Definitions
Actuator Definitions
Interconnect Definitions
TREETOPS files:

Summer Solstice (SS): .int, .lin, los.dat, solar_pressure.dat, excerpt of .flx

		Table	e A.2.1 S	Sensor Definition	s (C	Concept 2A and 2B)
Global Sensor Output	TREETOPS Sensor	Local Sensor Output No.	Sensor Mount Loc.	Туре	u s e d	DOF
No. RP1 RP2	Designation SE 1	1 2	B2-N2 B2-N2	Earth Target (ET) (LOS Along X ^{B2})		Pitch (YB2) Error – Overall System Yaw (ZB2) Error – Overall System
RP3 RP4	SE 2 SE 2 SE 2	1 2 3	B2-N2 B2-N2 B2-N2	Star Tracker (ST) (LOS Along Z ^{B2})		Roll (X ^{B2}) Error – Overall System Not used in control (Pitch (Y ^{B2}) Error) Not used in control (Validity Flag on(1) off(0))
RP5 RP6 RP7	SE 3	1 2	B3-N2 B3-N2	LOS Sensor (L) (LOS Along -Y ¹)		Roll (X ^{B3}) Error – Upper Clamshell Pitch (Y ^{B3}) Error – Upper Clamshell Not used in control, Yaw (Z ^{B3}) Error – Upper Clamshell
RP8 RP9	SE 3 SE 3 SE 3	3 4 5	B3-N2 B3-N2 B3-N2	(Negative Polar Axis) see .los file		Not used in control Not used in control
RP11 RP12	SE 3 SE 3	7	B3-N2 B3-N2 B4-N2			Not used in control Not used in control Roll (X ^{B4}) Error – Lower Clamshell
RP13 RP14 RP15	SE 4 SE 4 SE 4	2 3	B4-N2 B4-N2 B4-N2	LOS Sensor (L) (LOS Along +Y ¹)		Pitch (Y ^{B4}) Error – Lower Clamshell Not used in control, Yaw (Z ^{B4}) Error – Lower Clamshell
RP16 RP 17 RP 18	SE 4 SE 4 SE 4	5 6	B4-N2 B4-N2 B4-N2	(Positive Polar Axis) see .los file		Not used in control Not used in control Not used in control
RP 19 RP 20	SE 4 SE 5	7	B4-N2 B2-N5	Star Tracker (ST)		Not used in control Not used in control (Yaw (ZB2) Error
RP 21 RP 22	SE 5 SE 5	3	B2-N5 B2-N5	(LOS Along –X ^{B2}) (Towards Sun) 3 Axis Accelerometer		Not used in control (Pitch (Y ^{B2}) Error) Validity Flag on(1) off(0) Used for Rad Pres Disturb Not used in control, For Output Only, ACCEL (X ^{B2})
RP 23 RP 24 RP 25	SE 6 SE 6	2 3	B2-N2 B2-N2 B2-N2	(A3) with gravity removed		Not used in control, For Output Only, ACCEL (Y ^{B2}) Not used in control, For Output Only, ACCEL (Z ^{B2})

				Concept 2A and 2B)
Global Actuator Input No.	TREETOPS Actuator Designation	Sensor Mount Loc.	Туре	DOF
UP 1	AC I	B2-N2	Moment Actuator (MO)*	Pitch (Y ^{B2}) Ext. Torque – Overall System
UP 2	AC 2	B2-N2	Moment Actuator (MO)*	Yaw (ZB2) Ext. Torque - Overall System
UP 3	AC 3	B2-N2	Moment Actuator (MO)*	Roll (XB2) Ext. Torque – Overall System
UP 4	AC 4	B3-N2	Moment Actuator (MO)*	Roll (XB3) Ext. Torque – Upper Clamshell
UP 5	AC 5	B3-N2	Moment Actuator (MO)*	Pitch (Y ^{B3}) Ext. Torque – Upper Clamshel
UP 6	AC 6	B4-N2	Moment Actuator (MO)*	Roll (XB4) Ext. Torque - Lower Clamshell
UP 7	AC 7	B4-N2	Moment Actuator (MO)*	Pitch (YB4) Ext. Torque - Lower Clamshel
UP 8	AC 8	B2-N5	Reaction Jet (J) Radiation Pressure Disturbance	-X ^{B2} Force at Central Body Transmitter

Table A.2.3: Interconnect Data and Significant Parameters for TREETOPS Continuous Matrix (CM) Controller (Concept 2A and 2B)

	Interconnec	Significant Parameters in Continuous Matrix (CM) Controller in .lin file xdot = Ax + Bu y = Cx + Du							
Inter- connect	Description	S C C A	S No. C No. C No. A No.	S Out No. C In No. C Out No. A In No.	Gain N-m or N	Subset of A Matrix	Subset of B Matrix	Subset of C Matrix ω ² 2ζω	Subset of D Matrix
IC 1	Pitch (YB2) of Overall System	S C C	<u>l</u> 1	1 1 1	4.41E13	0. 1.	0	.000025 .007	0
IC 3	Yaw (Z ^{B2}) of Overall System	A S C C	1	2 2	1.67E12	0. 1.	0	.000025 .007	0
IC 4 IC 5 IC 6	Roll (X ^{B2}) of Overall System	A S C C	2 1	1 3 3	4.31E13	0. 1.	0	.000025 .007	0
IC 7	Roll (X ^{B3}) of Upper Clamshell	A S C	3	1 4	1.7E12	0. 1.	0	.0001 .014	0
IC 8	Roll (X) of Opper Clamster	C A S	1 4 3	4 1 2	1.0 1.7E12	-11.4 0. 1.	0		
IC 9	Pitch (Y ^{B3}) of Upper Clamshell	C C A	1 1 5	5 5	1.0	-11.4	1	.0001 .014	0
IC 11	Roll (X ^{B4}) of Lower Clamshell	S C C	4 1 1	6	1.7E12	0. 1.	1	.0001 .014	0
IC 13	Pitch (Y ^{B4}) of Lower Clamshell	A S C	6 4 1 1	1 2 7 7	1.7E12	0. 1.	0	.0001 .014	0
IC 15	-X ^{B2} of Radiation Pres Disturb	A S A	7 5 8	3	7.0				

isc3_flex_sol.int (Concept 2A) Summer Solstice

TREETOPS REV 10P2 4/10/00

SIM CONTROL

2 3 4 5 6 7 8	SI SI SI SI SI SI SI SI	O Title O Simulation stop time O Plot data interval O Integration type (R,S,U, OR V) O Step size (sec) O Sandia ODE solver absolute and relative error O RK78 ODE solver absolute error and first step size O Linearization option (L,Z or N) O Restart option (Y/N)	100000 20 R .1	THIRD VERSION
	SI SI	O Constraint force computation option (Y/N)	N	
	SI	O Small angle speedup option (All, Bypass, First, Nth)	A	
	SI	O Mass matrix speedup option (All, Bypass, First, Nth)	A	
	SI	O Non-Linear speedup option (All, Bypass, First, Nth)	A	
15	SI	O Constraint speedup option (All, Bypass, First, Nth)	A	
16	SI	O Constraint stabilization option (Y/N)	N	
17	SI	0 Stabilization epsilon		

GENGRAV

18 GG	1 Input gravity constants: GME, ERAD, EMASS	N
20 GG 21 GG		
21 GC	- $ -$	
23 GG	0 Day, Month, Year,	21 6 2020
24 GC		0
25 GC	0 Solar Pressure forces Y/N?	Y
26 GC		N
27 GC		
28 GC		
29 GC	; 1 Geomagnetic index, GEAP	

BODY

3.0	во	1	Body ID number	1
	во	1	Type (Rigid, Flexible, NASTRAN)	F
	во	1	Number of modes	24
33	BO	1	Modal calculation option (0, 1 or 2)	2
34	BO	1	Foreshortening option (Y/N)	
35	ВО	1	Model reduction method (NO, MS, MC, CC, QM, CV)	
36	BO	1	NASTRAN data file FORTRAN unit number (40 - 60)	
37	BO	1	Number of augmented nodes (0 if none)	
38	BO	1	Damping matrix option (NS,CD,HL,SD)	
39	во	1	Constant damping ratio	
40	BO	1	Low frequency, High frequency ratios	
41	BO	1	Mode ID number, damping ratio	
42	BO	1	Conversion factors: Length, Mass, Force	1
43	BO	1	Inertia reference node (0=Bdy Ref Frm; 1=mass cen)	6.2852173E11 6.2852173E11
_	BO		Moments of inertia (kg-m2) Ixx, Iyy, Izz	0.2032173211 0.20011 0.200
	573521	28	Tura Tura Tura	0 0 0
	во		Products of inertia (kg-m2) Ixy, Ixz, Iyz	1.6168633E5
	BO		Mass (kg)	4
	BO		Number of Nodes	1 0 0 0
	BO	1	Node ID, Node coord. (meters) x,y,z	2 0 0 0
	BO	1	Node ID, Node coord. (meters) x,y,z	3 0 0 3188.8
	BO	1	Node ID, Node coord. (meters) x,y,z	4 0 0 -3188.8
	во	1	Node ID, Node coord. (meters) x,y,z	• • • • • • • • • • • • • • • • • • • •
52	BO	1	Node ID, Node structual joint ID	

```
2 Body ID number
 53 BO
          2 Type (Rigid, Flexible, NASTRAN)
  54 BO
          2 Number of modes
  55 BO
          2 Modal calculation option (0, 1 or 2)
  56 BO
  57 BO 2 Foreshortening option (Y/N)
  58 BO 2 Model reduction method (NO,MS,MC,CC,QM,CV)
 59 BO 2 NASTRAN data file FORTRAN unit number (40 - 60) 60 BO 2 Number of augmented nodes (0 if none)
  61 BO 2 Damping matrix option (NS,CD,HL,SD)
  62 BO 2 Constant damping ratio
 63 BO 2 Low frequency, High frequency ratios 64 BO 2 Mode ID number, damping ratio
  65 BO 2 Conversion factors: Length, Mass, Force
  66 BO 2 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
                                                              .8543E12 1.5601E12
          2 Moments of inertia (kg-m2) Ixx, Iyy, Izz
  67 BO
1.3822E12
  68 BO 2 Products of inertia (kg-m2) Ixy, Ixz, Iyz
                                                                      0 0 0
                                                                        12666300
 70 BO 2 Mass (kg)
70 BO 2 Number of Nodes
71 BO 2 Node ID, Node coord. (meters) x,y,z
                                                                        1 298.323 0 0
 72 BO 2 Node ID, Node coord. (meters) x,y,z
73 BO 2 Node ID, Node coord. (meters) x,y,z
74 BO 2 Node ID, Node coord. (meters) x,y,z
                                                                      2 0 0 0
                                                                       3 0 0 300
                                                                       4 0 0 -300
                                                                       5 500 0 0
  75 BO 2 Node ID, Node coord. (meters) x,y,z
  76 BO 2 Node ID, Node structual joint ID
                                                                        3
           3 Body ID number
  77 BO
  78 BO 3 Type (Rigid, Flexible, NASTRAN)
                                                                        R
  79 BO 3 Number of modes
           3 Modal calculation option (0, 1 or 2)
  80 BO
          3 Foreshortening option (Y/N)
  81 BO
          3 Model reduction method (NO,MS,MC,CC,QM,CV)
  82 BO
          3 NASTRAN data file FORTRAN unit number (40 - 60)
3 Number of augmented nodes (0 if none)
  83 BO
  84 BO
          3 Damping matrix option (NS,CD,HL,SD)
  85 BO
          3 Constant damping ratio
  86 BO
           3 Low frequency, High frequency ratios
  87 BO
          3 Mode ID number, damping ratio
  88 BO
          3 Conversion factors: Length, Mass, Force
  89 BO
          3 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
3 Moments of inertia (kg-m2) Ixx, Iyy, Izz 1.7E12 1.7E12 3.4E12
3 Moments of inertia (kg-m2) Ixx, Iyz, Iyz 0 0 0
  90 BO
  91 BO
          3 Products of inertia (kg-m2) Ixy, Ixz, Iyz
  92 BO
                                                                       2046600
          3 Mass (kg)
  93 BO
           3 Number of Nodes
  94 BO
                                                                        1 0 0 0
           3 Node ID, Node coord. (meters) x,y,z
  95 BO
                                                                        2 0 0 0
          3 Node ID, Node coord. (meters) x,y,z
  96 BO
          3 Node ID, Node structual joint ID
  97 BO
           4 Body ID number
  98 BO
          4 Type (Rigid, Flexible, NASTRAN)
  99 BO
           4 Number of modes
 100 BO
           4 Modal calculation option (0, 1 or 2)
 101 BO
          4 Foreshortening option (Y/N)
 102 BO
          4 Model reduction method (NO,MS,MC,CC,QM,CV)
4 NASTRAN data file FORTRAN unit number (40 - 60)
 103 BO
 104 BO
          4 Number of augmented nodes (0 if none)
 105 BO
          4 Damping matrix option (NS,CD,HL,SD)
 106 BO
           4 Constant damping ratio
 107 BO
           4 Low frequency, High frequency ratios
  108 BO
           4 Mode ID number, damping ratio
          4 Conversion factors: Length, Mass, Force
4 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
 110 BO
 112 BO 4 Moments of inertia (kg-m2) Ixx, Iyy, Izz 1.7E12 1.7E12 3.4E12
 111 BO
 113 BO 4 Products of inertia (kg-m2) Ixy, Ixz, Iyz
                                                                         2046600
           4 Mass (kg)
  114 BO
  115 BO 4 Number of Nodes
                                                                        1 0 0 0
  116 BO 4 Node ID, Node coord. (meters) x,y,z
 117 BO 4 Node ID, Node coord. (meters) x,y,z
118 BO 4 Node ID, Node structual joint ID
                                                                         2 0 0 0
```

119 HI	1 Hinge ID number	1
120 HI	1 Inboard body ID, Outboard body ID	0 1 0 2
121 HI	1 "p" node ID, "q" node ID	3 F
122 HI	1 Number of rotation DOFs, Rotation option (F or G)	1 0 0
123 HI	1 L1 unit vector in inboard body coord. x,y,z 1 L1 unit vector in outboard body coord. x,y,z	1 0 0
124 HI	1 L2 unit vector in inboard body coord. x,y,z	
125 HI 126 HI	1 to unit vector in outboard body coord. X,Y,Z	
120 HI	1 13 unit vector in inboard body coord. X, Y, Z	0 0 1
128 HI	1 L3 unit vector in outboard body coord. x,y,z	0 0 1
129 HI	1 Initial rotation angles (deg)	-90 0 90 0 0 0.00417807
130 HI	1 Initial rotation rates (deg/sec)	0 0 0.00417007
131 HI	1 Rotation stiffness (newton-meters/rad)	0 0 0
132 HI	1 Rotation damping (newton-meters/rad/sec) 1 Null torque angles (deg)	0 0 0
133 HI	1 Number of translation DOFs	3
134 HI 135 HI	1 First translation unit vector g1	1 0 0
136 HI	1 Second translation unit vector g2	0 1 0
137 HI	1 Third translation unit vector g3	0 0 1 0 0 42163421
138 HI	1 Initial translation (meters)	3074.681 0 0
139 HI	1 Initial translation velocity (meters/sec)	0 0 0
140 HI	1 Translation stiffness (newtons/meters) 1 Translation damping (newtons/meter/sec)	0 0 0
141 HI	1 Null force translations	0 0 0
142 HI	I NUIT FOICE CLAMSTACTOMS	
143 HI	2 Hinge ID number	2
144 HI	2 Inboard body ID, Outboard body ID	1 2
145 HI	2 "p" node ID, "q" node ID	2 2
146 HI	2 Number of rotation DOFs	0 0 0 1
1 4 7 HI	2 L1 unit vector in inboard body coord. x,y,z	0 0 1
148 HI	2 L1 unit vector in outboard body coord. x,y,z 2 L2 unit vector in inboard body coord. x,y,z	
149 HI	2 L2 unit vector in outboard body coord. x,y,z	
150 HI 151 HI	2 t3 unit vector in inboard body coord, X,Y,Z	1 0 0
151 HI 152 HI	2 L3 unit vector in outboard body coord. x,y,z	1 0 0
153 HI	2 Initial rotation angles (deg)	0 0 0
154 HI	2 Initial rotation rates (deg/sec)	
155 HI	2 Rotation stiffness (newton-meters/rad)	
156 HI	2 Rotation damping (newton-meters/rad/sec) 2 Null torque angles (deg)	
157 HI	2 Number of translation DOFs	0
158 HI 159 HI	2 First translation unit vector g1	1 0 0
160 HI	2 Second translation unit vector g2	0 1 0
161 HI	2 Third translation unit vector g3	0 0 1 0 0
162 HI	2 Initial translation (meters)	0 0 0
163 HI	2 Initial translation velocity (meters/sec) 2 Translation stiffness (newtons/meters)	
164 HI	2 Translation stiffness (newtons/meters) 2 Translation damping (newtons/meter/sec)	
165 HI	2 Null force translations	
166 HI	Z Null Force didning	_
167 HI	3 Hinge ID number	3
168 HI	3 Inboard body ID, Outboard body ID	1 3 3 2
169 HI	3 "p" node ID, "q" node ID	2
170 HI	Number of rotation DOFs 1 L1 unit vector in inboard body coord. x,y,z	1 0 0
171 HI	3 L1 unit vector in outboard body coord. x,y,z	1 0 0
172 HI 173 HI	2 to unit vector in inboard body coord. X,Y,Z	0 1 0
174 HI	3 12 unit vector in outboard body coord. X,Y,Z	0 1 0
175 HI	2 13 unit vector in inboard body coord. X, Y, Z	
176 HI	3 L3 unit vector in outboard body coord. x,y,z	123.25 0. 0.
177 HI	3 Initial rotation angles (deg)	0 0
178 HI	3 Initial rotation rates (deg/sec) 3 Rotation stiffness (newton-meters/rad)	0 0
179 HI	3 Rotation damping (newton-meters/rad/sec)	0 0
180 HI 181 HI	3 Null torque angles (deg)	0 0
182 HI	3 Number of translation DOFs	0
183 HI	3 First translation unit vector gl	1 0 0 0 1 0
184 HI	3 Second translation unit vector g2	0 1 0

```
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Bd Systems®
                                                                                       NAS8-00151
TCD20000222A
                                                                                        Final Report
29 December 2000
                                                                     0 0 1
 185 HI 3 Third translation unit vector g3
                                                                     0 0 0
          3 Initial translation (meters)
 186 HI
         3 Initial translation velocity (meters/sec)
 187 HI
         3 Translation stiffness (newtons/meters)
         3 Translation damping (newtons/meter/sec)
3 Null force translations
 189 HI
 190 HI
 191 HI 4 Hinge ID number
          4 Inboard body ID, Outboard body ID
 192 HI
                                                                      4 2
         4 "p" node ID, "q" node ID
 193 HI
 194 HI 4 Number of rotation DOFs
 195 HI 4 L1 unit vector in inboard body coord. x,y,z
196 HI 4 L1 unit vector in outboard body coord. x,y,z
197 HI 4 L2 unit vector in inboard body coord. x,y,z
                                                                     1 0 0
                                                                      1 0 0
                                                                     0 1 0
                                                                     0 1 0
 198 HI \, 4 L2 unit vector in outboard body coord. x,y,z
 199 HI 4 L3 unit vector in inboard body coord. x,y,z
200 HI 4 L3 unit vector in outboard body coord. x,y,z
                                                                     33,25 0. 0.
 201 HI 4 Initial rotation angles (deg)
                                                                      0 0
 202 HI 4 Initial rotation rates (deg/sec)
         4 Rotation stiffness (newton-meters/rad)
4 Rotation damping (newton-meters/rad/sec)
 203 HI
                                                                     0.0
 204 HI
                                                                     0 0
 205 HI 4 Null torque angles (deg)
 206 HI 4 Number of translation DOFs
207 HI 4 First translation unit vector g1
                                                                      1 0 0
                                                                     0 1 0
 208 HI 4 Second translation unit vector g2
                                                                     0 0 1
 209 HI 4 Third translation unit vector g3
 210 HI 4 Initial translation (meters)
211 HI 4 Initial translation velocity (meters/sec)
                                                                      0 0 0
 212 HI 4 Translation stiffness (newtons/meters)
 213 HI 4 Translation damping (newtons/meter/sec)
214 HI 4 Null force translations
              SENSOR
  215 SE 1 Sensor ID number
 216 SE 1 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ET
           1 Mounting point body ID, Mounting point node ID
  217 SE
           1 Second mounting point body ID, Second node ID
  219 SE 1 Input axis unit vector (IA) x,y,z
          1 Mounting point Hinge index, Axis index
  220 SE
           1 First focal plane unit vector (Fp1) x,y,z
                                                                      0 0 -1
  221 SE
  222 SE 1 Second focal plane unit vector (Fp2) x,y,z
                                                                      0 1 0
          1 Sun/Star unit vector (Us) x,y,z
           1 Velocity Aberration Option (Y/N)
  224 SE
           1 Euler Angle Sequence (1-6)
  225 SE
          1 CMG ID number and Gimbal number
  226 SE
          1 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 6378000 0 0 4.178074D-3
  227 SE
           2 Sensor ID number
  228 SE
          2 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST
            2 Mounting point body ID, Mounting point node ID
  230 SE
            2 Second mounting point body ID, Second node ID
  231 SE
           2 Input axis unit vector (IA) x,y,z
           2 Mounting point Hinge index, Axis index
  232 SE
  233 SE
                                                                       0 -1 0
           2 First focal plane unit vector (Fp1) x,y,z
  234 SE
                                                                      1 0 0
           2 Second focal plane unit vector (Fp2) x,y,z
  235 SE
                                                                       0 1 0
           2 Sun/Star unit vector (Us) x,y,z
  236 SE
           2 Velocity Aberration Option (Y/N)
  237 SE
           2 Euler Angle Sequence (1-6)
  238 SE
           2 CMG ID number and Gimbal number
  239 SE
          2 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
  240 SE
           3 Sensor ID number
  241 SE
          3 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) L
  242 SE
           3 Mounting point body ID, Mounting point node ID
3 Second mounting point body ID, Second node ID
  243 SE
  244 SE
                                                                       1 2 3
           3 Input axis unit vector (IA) x,y,z
  245 SE
           3 Mounting point Hinge index, Axis index
  246 SE
            3 First focal plane unit vector (Fp1) x,y,z
  248 SE 3 Second focal plane unit vector (Fp2) x,y,z
```

Bd Systems® TCD20000222A 29 December 2000 3 Sun/Star unit vector (Us) x,y,z 249 SE 3 Velocity Aberration Option (Y/N) 3 Euler Angle Sequence (1-6) 251 SE 3 CMG ID number and Gimbal number 252 SE 3 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 4 Sensor ID number 254 SE 4 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) L 255 SE 4 Mounting point body ID, Mounting point node ID 256 SE 4 Second mounting point body ID, Second node ID 257 SE 3 2 1 4 Input axis unit vector (IA) x,y,z 258 SE 4 Mounting point Hinge index, Axis index 259 SE 4 First focal plane unit vector (Fp1) x,y,z 260 SE 4 Second focal plane unit vector (Fp2) x,y,z 261 SE 262 SE 4 Sun/Star unit vector (Us) x,y,z 4 Velocity Aberration Option (Y/N) 263 SE 4 Euler Angle Sequence (1-6) 264 SE 4 CMG ID number and Gimbal number 265 SE 266 SE 4 Earth pt (rad,lat,lon,rotation [m/e, d, d, d/s]) 5 Sensor ID number 267 SE 5 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST 268 SE 5 Mounting point body ID, Mounting point node ID 269 SE 5 Second mounting point body ID, Second node ID 5 Input axis unit vector (IA) x,y,z 271 SE 5 Mounting point Hinge index, Axis index 272 SE 5 First focal plane unit vector (Fp1) x,y,z $0 \ 0 \ 1$ 273 SE 0 - 1 05 Second focal plane unit vector (Fp2) x,y,z 274 SE 0 0 0 5 Sun/Star unit vector (Us) x,y,z 275 SE N 5 Velocity Aberration Option (Y/N) 276 SE 5 Euler Angle Sequence (1-6) 277 SE 5 CMG ID number and Gimbal number 278 SE 5 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 279 SE 6 Sensor ID number 280 SE 6 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV A3 281 SE 6 Mounting point body ID, Mounting point node ID 6 Second mounting point body ID, Second node ID 283 SE 6 Input axis unit vector (IA) x,y,z 284 SE 6 Mounting point Hinge index, Axis index 285 SE 6 First focal plane unit vector (Fp1) x,y,z 286 SE 6 Second focal plane unit vector (Fp2) x,y,z 287 SE 6 Sun/Star unit vector (Us) x,y,z 288 SE 6 Velocity Aberration Option (Y/N) 289 SE 6 Euler Angle Sequence (1-6) 290 SE 6 CMG ID number and Gimbal number 291 SE 6 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 292 SE ACTR 1 Actuator ID number 293 AC MO 1 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 1 Actuator location; Node or Hinge (N or H) 295 AC 1 Mounting point body ID number, node ID number 2 2 296 AC 1 Second mounting point body ID, second node ID 297 AC 0 1 0 1 Output axis unit vector x,y,z 298 AC 1 Mounting point Hinge index, Axis index 299 AC 1 Rotor spin axis unit vector x,y,z 300 AC 1 Initial rotor momentum, H 301 AC 1 Outer gimbal- angle(deg), inertia, friction(D, S, B, N) 302 AC 1 Outer gimbal axis unit vector x,y,z 303 AC 1 Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 304 AC 1 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 305 AC 1 Inner gimbal axis unit vector x,y,z 306 AC 1 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 307 AC 1 Initial length and rate, y(to) and ydot(to) 308 AC 1 Constants; K1 or wo, n or zeta, Kg, Jm 309 AC 1 Non-linearities; TLim, Tco, Dz 310 AC

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2 Actuator ID number

311 AC

Contract No. NAS8-00151 Final Report

29 DE	ecemb	er	2000	MO
312	AC	2	Type (T. H. MO, T. B. MA, SG, DG, W, D, M. T. M.	110
313	AC	2	Actuator location; Node or Hinge (N or H)	2 2
314	AC	2	Mounting hollie body in humber, house to manner	
315	AC	2	Second mounting point body ID, second node ID	0 0 1
316	AC	2	Output axis unit vector x,y,2	
317		2	Mounting point Hinge index, Axis index	
318	AC	2	Rotor spin axis unit vector x,y,z	
319		2	<pre>Initial rotor momentum, H Outer gimbal- angle(deg),inertia,friction(D,S,B,N)</pre>	
320		2	Outer gimbal axis unit vector x,y,z	
321		2	Outer gimbal axis unit vector K_1, M_2 . Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)	
322		2	Inner gimbal- angle(deg), inertia, friction(D, S, B, N)	
323		2	Inner gimbal axis unit vector x,y,z	
324		2	In gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k)	
325 326		2	Initial length and rate, y(to) and ydot(to)	
327		2	Constants; K1 or wo, n or zeta, Kg, Jm	
328		2	Non-linearities; TLim, Tco, Dz	
220				2
329	AC	3	Actuator ID number	3
330		3	Type $(J, H, MO, T, B, MA, SG, DG, W, L, MI-M/)$	MO
331		2	Actuator location: Node or Hinge (N or H)	2 2
332	AC	3	Mounting point body ID number, node ID number	2 2
333	AC	3	Second mounting point body ID, second node ID	1 0 0
334	AC	3	Output axis unit vector x,y,z	1 0 0
335	AC	3	Mounting point Hinge index, Axis index	
	AC	3	Rotor spin axis unit vector x,y,z	
	AC	3	<pre>Initial rotor momentum, H Outer gimbal- angle(deg),inertia,friction(D,S,B,N)</pre>	
	AC	3	Outer gimbal axis unit vector x,y,z	
	AC	3	Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k)	
	AC	3	Inner gimbal- angle(deg), inertia, friction(D, S, B, N)	
	AC	3	Inner gimbal axis unit vector X,Y,Z	
	AC AC	3	In aim fric (Tfi, Tafo, GAM)/(Tfi, M, D, Ki)/(m, M, B, K)	
	AC	3	Initial length and rate, y(to) and ydot(to)	
	AC	3	Constants: K1 or wo, n or zeta, Kg, Jm	
	AC	3	Non-linearities; TLim, Tco, Dz	
				1
347	AC	4	Actuator ID number	4 MO
	AC AC	1	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1,M)	4 MO
348 349	AC AC	4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location: Node or Hinge (N or H)	MO
348 349 350	AC AC AC	4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number	
348 349 350 351	AC AC AC AC	4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID	MO
348 349 350 351 352	AC AC AC AC AC AC	4 4 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z	MO 3 2
348 349 350 351 352 353	AC AC AC AC AC AC AC AC	4 4 4 4 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index	MO 3 2
348 349 350 351 352 353	AC A	4 4 4 4 4 4 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z	MO 3 2
348 349 350 351 352 353 354	AC A	4 4 4 4 4 4 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N)	MO 3 2
348 349 350 351 352 353 356 356	AC A	4 4 4 4 4 4 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg),inertia,friction(D,S,B,N)	MO 3 2
348 349 350 351 352 353 356 356 356	AC A	4 4 4 4 4 4 4 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)	MO 3 2
348 349 350 351 352 353 356 356 357	AC A	4 4 4 4 4 4 4 4	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N)	MO 3 2
348 349 350 351 352 353 354 355 356 358	AC A	44 44 44 44 44 44 44 44 44 44 44 44 44	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N)	MO 3 2
348 349 350 351 352 356 356 356 356 358 360	AC A	44 44 44 44 44 44 44 44	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z	MO 3 2
348 349 350 351 352 353 356 358 358 360 360	AC A	44 44 44 44 44 44 44 44 44 44 44 44 44	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal axis unit vector x,y,z Inner gimbal axis unit vector x,y,z Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to)	MO 3 2
348 349 350 351 352 353 356 359 360 361 361	AC A	44 44 44 44 44 44 44 44 44 44 44 44 44	Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm	MO 3 2
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348 349 350 351 352 353 353 353 353 363 363 363 363 363 363	3 AC 3 AC 3 AC 4 AC 5 AC 6 AC 6 AC 6 AC 7 AC 8 AC 6 AC 7 AC 8 AC		Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; Ki or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) Inner gimbal- angle(deg), inertia, friction(D,S,B,N)	MO 3 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
348 349 350 351 352 353 355 356 357 361 361 362 363 363 363 363 363 37 37 37 37 37 37 37 37	3 AC 3 AC 4 AC 5 AC 6 AC 7 AC 8 AC 6 AC 7 AC 8 AC 7 AC		Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal axis unit vector x,y,z Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal- angle(deg), inertia, friction(D,S,B,N) Inner gimbal axis unit vector x,y,z In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) Initial length and rate, y(to) and ydot(to) Constants; K1 or wo, n or zeta, Kg, Jm Non-linearities; TLim, Tco, Dz Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number Second mounting point body ID, second node ID Output axis unit vector x,y,z Mounting point Hinge index, Axis index Rotor spin axis unit vector x,y,z Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Outer gimbal- angle(deg), inertia, friction(D,S,B,N) Thner gimbal- angle(deg), inertia, friction(D,S,B,N)	MO 3 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Bd Systems® TCD20000222A 29 December 2000 5 Initial length and rate, y(to) and ydot(to) 380 AC 5 Constants; K1 or wo, n or zeta, Kg, Jm 381 AC 5 Non-linearities; TLim, Tco, Dz 382 AC 6 Actuator ID number 383 AC 6 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) MO 6 Actuator location; Node or Hinge (N or H) 385 AC 6 Mounting point body ID number, node ID number 4 2 386 AC 6 Second mounting point body ID, second node ID 387 AC 1 0 0 6 Output axis unit vector x,y,z 388 AC 6 Mounting point Hinge index, Axis index 389 AC 6 Rotor spin axis unit vector x,y,z 390 AC 6 Initial rotor momentum, H 391 AC 6 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 392 AC 6 Outer gimbal axis unit vector x,y,z 393 AC 6 Out gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k)394 AC 6 Inner gimbal- angle(deg), inertia, friction(D, S, B, N) 395 AC 6 Inner gimbal axis unit vector x,y,z 396 AC 6 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 397 AC 6 Initial length and rate, y(to) and ydot(to) 398 AC 6 Constants; K1 or wo, n or zeta, Kg, Jm 399 AC 6 Non-linearities; TLim, Tco, Dz 400 AC 7 Actuator ID number 401 AC MO 7 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 402 AC 7 Actuator location; Node or Hinge (N or H) 403 AC 7 Mounting point body ID number, node ID number 4 2 404 AC 7 Second mounting point body ID, second node ID 405 AC 0 1 0 7 Output axis unit vector x,y,z 406 AC 7 Mounting point Hinge index, Axis index 407 AC 7 Rotor spin axis unit vector x,y,z 408 AC 7 Initial rotor momentum, H 409 AC 7 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 410 AC 7 Outer gimbal axis unit vector x,y,z 411 AC 7 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 412 AC 7 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 413 AC 7 Inner gimbal axis unit vector x,y,z 414 AC 7 In gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k)415 AC 7 Initial length and rate, y(to) and ydot(to) 416 AC 7 Constants; K1 or wo, n or zeta, Kg, Jm 417 AC 7 Non-linearities; TLim, Tco, Dz 418 AC 8 8 Actuator ID number 419 AC 8 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 420 AC 8 Actuator location; Node or Hinge (N or H) 421 AC 8 Mounting point body ID number, node ID number 2 5 422 AC 8 Second mounting point body ID, second node ID 423 AC -1 0 0 8 Output axis unit vector x,y,z 424 AC 8 Mounting point Hinge index, Axis index 425 AC 8 Rotor spin axis unit vector x,y,z 426 AC 8 Initial rotor momentum, H 427 AC 8 Outer gimbal- angle(deg), inertia, friction(D, S, B, N) 428 AC 8 Outer gimbal axis unit vector x,y,z 429 AC 8 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 430 AC 8 Inner gimbal- angle(deg), inertia, friction(D,S,B,N) 431 AC 8 Inner gimbal axis unit vector x,y,z 432 AC 8 In gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 433 AC 8 Initial length and rate, y(to) and ydot(to) 434 AC 8 Constants; K1 or wo, n or zeta, Kg, Jm 435 AC 8 Non-linearities; TLim, Tco, Dz 436 AC CONTROLLER 437 CO 1 Controller ID number 1 Controller type (CB,CM,DB,DM,UC,UD) CM438 CO 1 Sample time (sec) 439 CO 7 7 1 Number of inputs, Number of outputs 440 CO 1 Number of states 441 CO 1 Output No., Input type (I,S,T), Input ID, Gain

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INTERCONNECT

443 444 445 446	IN IN	<pre>1 Interconnect ID number 1 Source type(S,C, or F),Source ID,Source row # 1 Destination type(A or C),Dest ID,Dest row # 1 Gain</pre>	1 S 1 1 C 1 1 4.41E13
447 448 449 450	IN IN	<pre>2 Interconnect ID number 2 Source type(S,C, or F),Source ID,Source row # 2 Destination type(A or C),Dest ID,Dest row # 2 Gain</pre>	2 C 1 1 A 1 1 1.
451 452 453 454	IN IN	<pre>3 Interconnect ID number 3 Source type(S,C, or F),Source ID,Source row # 3 Destination type(A or C),Dest ID,Dest row # 3 Gain</pre>	3 S 1 2 C 1 2 1.67E12
455 456 457 458	IN IN	4 Interconnect ID number 4 Source type(S,C, or F),Source ID,Source row # 4 Destination type(A or C),Dest ID,Dest row # 4 Gain	4 C 1 2 A 2 1
459 460 461 462	IN IN	<pre>5 Interconnect ID number 5 Source type(S,C, or F),Source ID,Source row # 5 Destination type(A or C),Dest ID,Dest row # 5 Gain</pre>	5 S 2 1 C 1 3 4.31E13
463 464 465 466	IN IN	<pre>6 Interconnect ID number 6 Source type(S,C, or F),Source ID,Source row # 6 Destination type(A or C),Dest ID,Dest row # 6 Gain</pre>	6 C 1 3 A 3 1
469	IN IN IN	<pre>7 Interconnect ID number 7 Source type(S,C, or F),Source ID,Source row # 7 Destination type(A or C),Dest ID,Dest row # 7 Gain</pre>	7 S 3 1 C 1 4 1.7E12
472 473	IN IN IN	<pre>8 Interconnect ID number 8 Source type(S,C, or F),Source ID,Source row # 8 Destination type(A or C),Dest ID,Dest row # 8 Gain</pre>	8 C 1 4 A 4 1 1
476 477	IN IN IN	<pre>9 Interconnect ID number 9 Source type(S,C, or F),Source ID,Source row # 9 Destination type(A or C),Dest ID,Dest row # 9 Gain</pre>	9 S 3 2 C 1 5 1.7E12
480 481	IN IN IN	10 Interconnect ID number 10 Source type(S,C, or F), Source ID, Source row # 10 Destination type(A or C), Dest ID, Dest row # 10 Gain	10 C 1 5 A 5 1
484 485	IN IN IN	<pre>11 Interconnect ID number 11 Source type(S,C, or F),Source ID,Source row # 11 Destination type(A or C),Dest ID,Dest row # 11 Gain</pre>	11 S 4 1 C 1 6 1.7E12
488 489	IN IN IN	12 Interconnect ID number 12 Source type(S,C, or F),Source ID,Source row # 12 Destination type(A or C),Dest ID,Dest row # 12 Gain	12 C 1 6 A 6 1
492 493	IN IN IN	13 Interconnect ID number 13 Source type(S,C, or F),Source ID,Source row # 13 Destination type(A or C),Dest ID,Dest row # 13 Gain	13 S 4 2 C 1 7 1.7E12
496	S IN S IN 7 IN	14 Interconnect ID number 14 Source type(S,C, or F),Source ID,Source row # 14 Destination type(A or C),Dest ID,Dest row #	14 C 1 7 A 7 1

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Contract No.
NAS8-00151
Final Report
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Bd Systems®
TCD20000222A
29 December 2000
498 IN 14 Gain

499 IN 15 Interconnect ID number
500 IN 15 Source type(S,C, or F), Source ID, Source row # S 5 3
501 IN 15 Destination type(A or C), Dest ID, Dest row # A 8 1
502 IN 15 Gain
```

isc3_flex_sol.lin (Concept 2A) Summer Solstice

```
* Controller for integrated symmetrical concentrator
system CONT1 14,7,7,0,0,0.0
*A
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
-1 -1.4 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0
0 0 -1 -1.4 0 0 0 0 0 0 0 0 0 0
0 \ 0 \ 0 \ 0 \ -1 \ -1.4 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0
0 0 0 0 0 0 0 1 0 0 0 0 0
\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & -1 & -1 & .4 & 0 & 0 & 0 & 0 & 0 \end{smallmatrix}
0 0 0 0 0 0 0 0 -1 -1.4 0 0 0
0 0 0 0 0 0 0 0 0 0 -1 -1.4 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 -1 -1.4
*B
0 0 0 0 0 0 0
1 0 0 0 0 0 0
0 0 0 0 0 0 0
0 1 0 0 0 0 0
0 0 0 0 0 0 0
0 0 1 0 0 0 0
0 0 0 0 0 0 0
0 0 0 1 0 0 0
0 0 0 0 0 0 0
0 0 0 0 1 0 0
0 0 0 0 0 0 0
0 0 0 0 0 1 0
0 0 0 0 0 0 0
0 0 0 0 0 0 1
 .000025 .007 0 0 0 0 0 0 0 0 0 0 0
0 0 .000025 .007 0 0 0 0 0 0 0 0 0 0
0 0 0 0 .000025 .007 0 0 0 0 0 0 0 0
\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & .0001 & .014 & 0 & 0 & 0 & 0 & 0 \end{smallmatrix}
0 0 0 0 0 0 0 0 .0001 .014 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 .0001 .014 0 0
*D
 0 0 0 0 0 0 0
 0 0 0 0 0 0 0
 0 0 0 0 0 0 0
 0 0 0 0 0 0 0
 0 0 0 0 0 0 0
 0 0 0 0 0 0 0
 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0
 * H
 *M
```

29 December 2000

los.dat (Concept 2A) Summer Solstice

```
Defaults to sun as a target for zero input vector
                Defaults to sun as a target for zero input vector
                                          Target star along negative polar axis
                                                                                                                                                                                                      Target star along positive polar axis
                                                                                                                                                        number of 2nd FGS (clamshell) sensor
! Sensor number of 1st FGS (clamshell) sensor
                                                                                                                                                                                                                                              Focal plane vector 2 Focal plane vector 3
                                                                                                            Focal plane vector 3
                                                                                                                                                                                                                              Focal plane vector 1
                                                                                         Focal plane vector 2
                                                                     Focal plane vector 1
                                                                                                                                                               : Sensor
                                             0.d0, -1.d0,0.d0,
                                                                                                                                                                                                         0.d0, 1.d0,0.d0,
0.d0,-1.d0,0.d0,
1.d0,0.d0,0.d0,
                                                                   0.d0,-1.d0,0.d0,
                                                                                                                                                                                                                                                                            -1.d0,0.d0,0.d0,
                                                                                         1.d0,0.d0,0.d0,
1.d0,0.d0,0.d0,
                                                                                                                                                                              0.d0,0.d0,0.d0,
                  0.d0,0.d0,0.d0,
```

solar pressure.dat (Concept 2A) Summer Solstice

```
! body, node, area, reflectivity factor,outward normal,centroid ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                ! body, node, area, reflectivity factor,outward normal,centroid ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                     ! body, node, area, reflectivity factor, outward normal, centroid ! body, node, area, reflectivity factor, outward normal, centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                              body, node, area, reflectivity factor, outward normal, centroid body, node, area, reflectivity factor, outward normal, centroid
                                                                                                                                                                                                                                                                                                                                                                           ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                           ! body, node, area, reflectivity factor, outward normal, centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                    ! body, node, area, reflectivity factor,outward normal,centroid ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                body, node, area, reflectivity factor, outward normal, centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         node, area, reflectivity factor,outward normal,centroid
                                         ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                  ! body, node, area, reflectivity factor,outward normal,centroid
2,3,785000.d0,0.0d0, 0.1736d0,0.d0,0.9848d0,0.d0,0.d0,0.d0, 2,3,785000.d0,0.0d0,-0.1736d0,1.d0,-0.9848d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             2,4,785000.d0,0.0d0, -0.1736d0,-1.d0,0.9848d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                2,4,785000.d0,0.0d0, 0.1736d0,0.d0,-0.9848d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    body,
                                                                                                                                                                                                                                                                                                       1,3,319000.00,0.5d0,-1.d0,0.d0,0.d0,0.d0,0.d0,-7.972d2,1,3,319000.d0,0.5d0,0.d0,-1.d0,0.d0,0.d0,0.d0,-7.972d2,1,4,319000.d0,0.5d0,1.d0,0.d0,0.d0,0.d0,0.d0,7.972d2,1,4,319000.d0,0.5d0,0.d0,1.d0,0.d0,0.d0,0.d0,7.972d2,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                           1,4,319000.d0,0.5d0,-1.d0,0.d0,0.d0,0.d0,0.d0,7.972d2,1,4,319000.d0,0.5d0,0.d0,-1.d0,0.d0,0.d0,0.d0,7.972d2,
                                                                                                                                                                                                                    1,3,319000.d0,0.5d0,1.d0,0.d0,0.d0,0.d0,0.d0,-7.972d2,
                                                                                                                                                                                                                                                                 1,3,319000.d0,0.5d0,0.d0,1.d0,0.d0,0.d0,0.d0,-7.972d2,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  2,5,196000.d0,0.0d0, 1.d0,0.d0,0.d0,0.d0,0.d0,0.d0,
                                                                                                                                     1,2,638000.d0,0.5d0,-1.d0,0.d0,0.d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                  1,2,638000.d0,0.5d0,0.d0,-1.d0,0.d0,0.d0,0.d0,0.d0
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     3,2,1.04d7,1.0d0,0.d0,0.d0,-1.d0,0.d0,0.d0,0.d0,4.2,1.04d7,1.0d0,0.d0,0.d0,1.d0,0.d0,0.d0,0.d0,4.2,1.04d7,1.0d0,0.d0,0.d0,0.d0,-1.d0,0.d0,0.d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            3,2,1.04d7,1.0d0,0.d0,0.d0,1.d0,0.d0,0.d0,0.d0,
```

isc3_flex_sol.flx (Concept 2A) Summer Solstice (An Excerpt)

```
flag, revision number
XXXXXX
                    1
  body id
         1
  modes, nodes, modal options
                                                              0
                                                   0
                              0
                   4
       24
                                                                                   0
                                                                        0
                                                   0
                                         0
         0
                   0
                              0
                                                                        0
                                                                                   0
                                                             0
                                         0
                                                   0
                              0
                   0
         n
                                                                                   0
                                                             0
                                                                        0
                                         0
                                                   0
                   0
                              0
  phi_t for node #
                                                                                 .31346273E-02
   .31310941E-02 -.16357954E-03 .19158607E-08 .68659216E-04
   .14949358E-08 -.33409338E-09 -.17910070E-08 -.62130721E-04
                                                                                 .10048928E-08
                                                                                 .56292416E-10
   .74260327E-10 -.81693812E-09 .66744219E-10 -.57300403E-09
                                         .41569313E-10 .36697769E-02
                                                                                 .69502051E-03
 -.31109642E-09 .51999889E-08
                                                                                 .61553749E-10
   .85567197E-10 -.10557893E-02 .35826871E-02 .65924560E-10
   .11085623E-08 -.67301328E-05 .49549244E-10 -.49437998E-08 -.60865848E-11
  .10484816E-08 .39239830E-10 -.17858973E-09 .46440350E-10 .23145265E-09
   .76239104E-11 -.98486197E-09 -.52382674E-09 .30708566E-12 .12143532E-10
 -.10722701E-09 .94529479E-03 .17735129E-08 .15323995E-09 .13868812E-12 -.13390485E-02 -.55272105E-04 -.82202021E-12 .55317399E-04 -.13390483E-02
 -.13390485E-02 -.55272105E-04 -.82202021E-12
   .27552836E-11 .29149021E-10 -.27567962E-12 -.44865972E-10 .48584658E-11
   .10595799E-10 -.31919479E-08 -.19937738E-10 .14255509E-09 -.23770452E-02
 -.45933446E-03 -.19673179E-04 .63985161E-12 -.19675549E-04 .45933391E-03 -.74265281E-12 -.34874105E-11 -.12587102E-11 .59687765E-09 -.12099360E-11
 -.69004494E-11 .19524343E-08
   phi_t prime for node #
   .17177767E-11 -.22808543E-11 -.45683561E-10 .19817016E-10 .56718933E-12
   .31514104E-09 .17463000E-11 -.27057756E-13 -.60467460E-12 .11400599E-06
 -.42543750E-05 -.11919737E-10 .42546793E-05 .10153760E-06 -.34352434E-10
   .41859459E-11 -.37080794E-11 .59234151E-04 .45504345E-11 -.70844966E-12
   .15588470E-10 .13593377E-10 .68741697E-12 .87795145E-10 -.28497036E-11 .31909564E-13 -.69421743E-15 .38765922E-11 -.41335440E-11 -.44983453E-04
   .22473012E-05 -.13022411E-04 .41075666E-11 -.13101519E-04 -.17274113E-05
  -.98017672E-11 -.14778531E-12 -.42275125E-13 -.96071643E-06 -.25440820E-11
   .54200130E-11 .41425181E-12 -.51084189E-13 .98880082E-15 .14899414E-06
  -.49351318E-14 .15066380E-14 -.42969795E-10 -.54223125E-14 .27635772E-15 
-.79851673E-11 .23444071E-06 -.40722409E-05 -.13017710E-13 .40722809E-05
   .23382333E-06 .64327760E-12 -.80030821E-11 .19070818E-11 .27557384E-13
   .67193209E-14 .15459451E-13 .15489036E-10 .28188639E-13 .15021236E-15
   .22611633E-11 -.61243211E-07 .17482812E-05 .30019490E-13 -.17482739E-05
  -.61449314E-07 -.27684414E-12
                                     3
   phi_t for node #
                                          .19835813E-08 -.36612814E-03 -.42534660E-02
  -.42404714E-02 .49480955E-03
  .96750031E-09 .42209027E-09 .30963712E-08 .40516924E-04 .38549281E-02 
-52714285E-03 -.87737477E-09 .53843743E-03 .38533672E-02 -.10363838E-09 
.38623427E-08 -.71743451E-08 .24131659E-03 .31427071E-02 -.10270931E-03
   .15812594E-09 -.20969267E-03 .31373775E-02 .44642715E-09 .28790083E-09
  .88009461E-09 .18408168E-03 -.17813513E-08 -.27431844E-08 .15957166E-04 -.19242852E-02 .34087019E-03 -.22330623E-09 .41716037E-03 .19091971E-02
                      .95016675E-09 -.81490514E-09 .32861442E-02 -.18116747E-08
  -.71605887E-10
   .55541036E-09 .79551900E-03 -.41608643E-08 -.26069981E-09 .94036451E-02
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Bd Systems® TCD20000222A

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.40357060E-08 .46272789E-08	32747580E-08	41693501E-0842365812E-01 23299565E-0833531355E-09
22743214E+0053395066E-09		.44221408E-0915144278E-09
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.23699116E-07 .12256696E-08	39578955E-08	.86543027E-0851209400E-08 - 13756098E-09 .74204357E-08
.21513879E-08 .22743389E+00		13756098E-09 .74204357E-08 .15144278E-09 .50250104E-02
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10011899E-08 .39672401E-09 18324191E-0958945067E-07		14363279E-0995706411E-02
	90178997E-09	.17350601E-08 .65747891E-02
17200040F-08 - 80376640E-09	30587738E-02	65962710E-0712765379E-06 .27202374E-09 .16763984E-06
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.78136072E-0929073755E-03	L13718954E-08	236/2818E-08 .42009921E-01
.12962772E+00 .22610792E+00		.34009417E-09 .36617465E-08 .26190706E-11 .53621168E-07
.44502412E-08 .82095560E-03	1 .12224359E+00 035302623E-07	
.78323735E-07 .76419772E-10 .16412533E-11 .21384164E-11		58936241E-1114505988E-10
- 33385669E-02 - 42306378E-1	13863650E-08	.83012671E-0856730240E-07
- 96467007E-07 - 10535633E-09	991711930E-07	.55460535E-0751525169E-09
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.54977989E-0938611032E-0	9 .12072820E-07	.17167179E-0184177208E-02
.13940941E-0783848781E-0	9 .30068531E-10	.41762028E-01 .19728023E-08

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50488788E-08 .25689226E-09	332032115E-0812223122E+00 .82113856E-01
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24482274E-07 .14363279E-0	9 - 58936241E-11 .14505988E-10 .33385669E-02
45134366E-09 .30239391E-0	32020344E-03 .31906173E-09 .34199546E-11
81669645E-0830329414E-0	5 - 66271809E-06 - 35363609E-09 - 66144997E-06
.30804574E-06 .20159786E-0	1 _ 57170319E=09 - 11035564E-08 - 1252/212E-02
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84602464E-1039083720E+0	0 .17696374E+00 .30//512/E-10 .12230033E 00
.79443691E-09 .63405973E-0	8 .15032889E-078020482/E-08 .2419/3/2E-00
.15146456E-06 .22667613E-0	6 .27864015E+00 .12645160E-06 .20146267E-06
.74812742E+00 .23320671E-0	1 .71358750E-0115696020E-0665869035E-07
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.31447785E-08 .59196241E-0	810223336E-07 .57668967E-08 .84437859E-08
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.48004147E-01 .21394263E-0	7 _ 9/233533E-10 - 50069943E-0911013084E-00
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.66271809E-06 .35363609E-0	9 17696591E+00 .39083612E+00 .84602464E-10
.34515937E-11 .11639133E-1	0 11823240E-03 .78122412E-1214089096E-10
	8 - 15892413E-07 .65356843E-10 .31383227E-07
72836582E-0246789915E-0 .10485630E-07 .42666551E-0	9 22686122E-06 - 15001301E-06 .75692354E+00
.20000508E-0612631014E-0	6 - 30143385E+00 .71358882E-0123320214E-01
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.51525169E-09 .66144997E-0	078122412E-12 .14089096E-10 .72836582E-02
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14618963E-09 .69521649E-	TOTACOD 10 05007134E 07
.22679544E-09 .44642344E-	1500013ED 05 77536046E 05
54382657E-06 .11012196E-	75 .105757512 05 12012
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.11419001E+00 .22910605E-	1240010ER 06
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41855726E-07 .41887505E-	ac 00110470D 01
16416114E-08 .28098883E-	
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19779770E-08 .13203123E-	0889135235E-0831354628E-01 .41849538E-02

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                              .73095770E-08 .34936258E+00 -.20008846E+00
 .10387562E-07 -.27226537E-08
                                             .18933107E-09 -.13611625E-06
              .21430064E-06 -.12189418E-06
.63215067E-07 -.27202374E-09 -.76083731E-11 -.16981023E-11 -.72526267E-02
              .57328140E-09 .29238966E-02 -.15032889E-07
                                                            .80204827E-08
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-.24197572E-08 -.31383227E-07 -.10485630E-07 -.42666551E-09 -.44642344E-07
 .22809491E-07 -.59107460E-10 -.84364044E-11 -.86915796E-11 -.68614717E-02
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(and more)

A.3 Concept 2B Definitions and TREETOPS files

Sensor Definitions **Actuator Definitions** Interconnect Definitions TREETOPS files:

Summer Solstice (SS):

.int, .lin, los.dat, solar_pressure.dat, excerpt of .flx

		Table	e A.3.1 S	Sensor Definitions	s (C	Concept 2A and 2B)
Global		Local			u s	
Sensor	TREETOPS	Sensor	Sensor		c d	
Output	Sensor	Output	Mount	Type	. "	DOF
No.	Designation	No.	Loc.			Pitch (YB2) Error - Overall System
RPI	SE 1	11	B2-N2	Earth Target (ET) (LOS Along X ^{B2})		Yaw (Z ^{B2}) Error – Overall System
RP2	SE 1	2	B2-N2			Roll (X ^{B2}) Error – Overall System
RP3	SE 2	1	B2-N2	Star Tracker (ST)		Not used in control (Pitch (Y ^{B2}) Error)
RP4	SE 2	2	B2-N2	(LOS Along Z ^{B2})	-	Not used in control (Validity Flag on(1) off(0))
RP5	SE 2	3	B2-N2			Roll (X ^{B1}) Error – Upper Clamshell
RP6	SE 3	1	B3N2			Pitch (Y ^{B3}) Error – Upper Clamshell
RP7	SE 3	2	B3-N2	LOS Sensor (L)		Not used in control, Yaw (Z ^{B3}) Error – Upper Clamshell
RP8	SE 3	3	B3-N2	(LOS Along -Y ¹) (Negative Polar Axis) see .los file		
RP9	SE 3	4	B3-N2			Not used in control
RP10	SE 3	5	B3-N2	see los file	<u> </u>	Not used in control
RP11	SE 3	6	B3-N2		<u> </u>	Not used in control
RP12	SE 3	7	B3-N2		<u></u>	Not used in control
RP13	SE 4		B4-N2			Roll (XB4) Error – Lower Clamshell
RP14	SE 4	2	B4-N2	LOS Sensor (L)		Pitch (YB4) Error – Lower Clamshell
RP15	SE 4	3	B4-N2	(LOS Along +Y ¹)	L.	Not used in control, Yaw (Z ^{B4}) Error – Lower Clamshel
RP16	SE 4	4	B4-N2	(Positive Polar Axis)	L_	Not used in control
RP 17	SE 4	5	B4-N2	see .los file	oxdot	Not used in control
RP 18	SE 4	6	B4-N2			Not used in control
RP 19	SE 4	7	B4-N2			Not used in control
RP 20	SE 5	1	B2-N5	Star Tracker (ST)	L	Not used in control (Yaw (Z ^{B2}) Error
RP 21	SE 5	1 2	B2-N5	(LOS Along –X ^{B2})		Not used in control (Pitch (Y ^{B2}) Error)
RP 22	SE 5	3	B2-N5	(Towards Sun)		Validity Flag on(1) off(0) Used for Rad Pres Disturb
RP 23	SE 6	1	B2-N2	3 Axis Accelerometer		Not used in control, For Output Only, ACCEL (XB2)
RP 24	SE 6	2	B2-N2	(A3) with		Not used in control, For Output Only, ACCEL (YB2)
RP 25	SE 6	$\frac{2}{3}$	B2-N2	gravity removed		Not used in control, For Output Only, ACCEL (Z ^{B2})

	Table A	.3.2 Ac	tuator Definitions (Concept 2A and 2B)
Global Actuator Input No.	TREETOPS Actuator Designation	Sensor Mount Loc.	Туре	DOF OverII System
UP 1	AC I	B2-N2	Moment Actuator (MO)*	Pitch (Y ^{B2}) Ext. Torque – Overall System Yaw (Z ^{B2}) Ext. Torque – Overall System
UP 2	AC 2	B2-N2	Moment Actuator (MO)*	Roll (X ^{B2}) Ext. Torque – Overall System
UP 3	AC 3	B2-N2	Moment Actuator (MO)*	Roll (X ^{B3}) Ext. Torque – Upper Clamshell
UP 4	AC 4	B3-N2	Moment Actuator (MO)*	Pitch (Y ^{B3}) Ext. Torque – Upper Clamshel
UP 5	AC 5	B3-N2	Moment Actuator (MO)*	Pitch (1) Ext. Torque - Opper Clambre
UP 6	AC 6	B4-N2	Moment Actuator (MO)*	Roll (XB4) Ext. Torque – Lower Clamshell
UP 7	AC 7	B4-N2	Moment Actuator (MO)*	Pitch (Y ^{B4}) Ext. Torque – Lower Clamshel
UP 8	AC 8	B2-N5	Reaction Jet (J) Radiation Pressure Disturbance	-X ^{B2} Force at Central Body Transmitter

Used in Control

Table A.3.3: Interconnect Data and Significant Parameters for TREETOPS Continuous Matrix (CM) Controller (Concept 2A and 2B)

Interconnect Data					Significant Parameters in Continuous Matrix (CM) Controller in .lin file xdot = Ax + Bu y = Cx + Du				
Inter- connect	Description	S C C A	S No. C No. C No. A No.	S Out No. C In No. C Out No. A In No.	Gain N-m or N	Subset of A Matrix	Subset of B Matrix	Subset of C Matrix ω² 2ζω	Subset of D Matrix
IC 1	Pitch (Y ^{B2}) of Overall System	S C C	<u>1</u> 1	1	4.41E13	0. 1.	0	.000025 .007	0
IC 3	Yaw (ZB2) of Overall System	A S C	1	2 2	1.67E12	0. 1.	0	.000025 .007	0
IC 4	Roll (X ^{B2}) of Overall System	C A S C	2 2	1 1 3	1.0 4.31E13	0. 1.	0	.000025 .007	0
IC 6	Kon (x) or o rainely	C A	1 3	3	1.0 1.7E12	-11.4 0. 1.	1		
IC 7	Roll (X ^{B3}) of Upper Clamshell	S C C A	3 1 1 4	4	1.7612	-11.4	1	.0001 .014	0
IC 9	Pitch (Y ^{B3}) of Upper Clamshell	S C C	3 1 1 5	5 5	1.7E12	0. 1.	1	.0001 .014	0
IC 11	Roll (X ^{B4}) of Lower Clamshell	S C C	1 1	6 6	1.7E12	0. 1.	0	.0001 .014	0
IC 13	Pitch (Y ^{B4}) of Lower Clamshell	A S C C	6 4 1	7	1.7E12	0. 1.	0	.0001 .014	0
IC 15	-X ^{B2} of Radiation Pres Disturb	A S A	5 8	3	7.0				

isc3 flex sol.int (Concept 2B) Summer Solstice

TREETOPS REV 10P2 4/10/00

SIM CONTROL

```
ISC MODEL, THIRD VERSION
        0 Title
1 SI
                                                                 100000
        0 Simulation stop time
 2 SI
                                                                 20
        0 Plot data interval
 3 SI
                                                                 R
       0 Integration type (R,S,U, OR V)
 4 SI
        0 Step size (sec)
 5 SI
        0 Sandia ODE solver absolute and relative error
 6 SI
       0 RK78 ODE solver absolute error and first step size
 7 SI
                                                                 N
       0 Linearization option (L,Z or N)
 8 SI
                                                                 N
       0 Restart option (Y/N)
9 SI
10 SI
                                                                 Y
                                                  (Y/N)
       O Contact force computation option
       0 Constraint force computation option (Y/N)
11 SI
       0 Small angle speedup option (All, Bypass, First, Nth)
                                                                 Α
12 SI
        0 Mass matrix speedup option (All, Bypass, First, Nth)
                                                                 Α
        0 Non-Linear speedup option (All, Bypass, First, Nth) A 0 Constraint speedup option (All, Bypass, First, Nth) A
13 SI
14 SI
15 SI
16 SI 0 Constraint stabilization option (Y/N)
       0 Stabilization epsilon
17 SI
           GENGRAV
```

```
5 Gravity, earth sphere/nonsphere/user (S/N/U)?
      1 Input gravity constants: GME, ERAD, EMASS
       1 Spherical or Nonspherical (S/N)?
20 GG
       1 Gravity Potential Harmonics J2,J3,J4
21 GG
       5 English (ft-slug-s) or metric (m-kg-s)
                                                   (E/M)?
22 GG
                                                            21 6 2020
       5 Day, Month, Year,
23 GG
       5 GMT @ sim time 0 (minutes past midnight,
                                                            0
24 GG
                                                            Y
       5 Solar Pressure forces Y/N?
25 GG
      5 Input new data for aero model? (Y/N)
                                                            N
      1 Solar flux F10 for aero model
26 GG
27 GG
           Solar flux, 81 day average F10B
28 GG
       1
       1 Geomagnetic index, GEAP
29 GG
```

BODY

```
1 Body ID number
 30 BO
        1 Type (Rigid, Flexible, NASTRAN)
 31 BO
                                                              24
       1 Number of modes
 32 BO
        1 Modal calculation option (0, 1 or 2)
 33 BO
       1 Foreshortening option (Y/N)
 34 BO
       1 Model reduction method (NO,MS,MC,CC,QM,CV)
       1 NASTRAN data file FORTRAN unit number (40 - 60)
 35 BO
 36 BO
         1 Number of augmented nodes (0 if none)
 37 BO
       1 Damping matrix option (NS,CD,HL,SD)
 38 BO
       1 Constant damping ratio
 39 BO
         1 Low frequency, High frequency ratios
 40 BO
        1 Mode ID number, damping ratio
 41 BO
       1 Conversion factors: Length, Mass, Force
       1 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
 42 BO
                                                              6.2852173E11 6.2852173E11
 43 BO
         1 Moments of inertia (kg-m2) Ixx, Iyy, Izz
 44 BO
6.7057352E8
       1 Products of inertia (kg-m2) Ixy, Ixz, Iyz
                                                              0 0 0
 45 BO
                                                              1.6168633E5
 46 BO
         1 Mass (kg)
 47 BO 1 Number of Nodes
                                                              1 0 0 0
 48 BO 1 Node ID, Node coord. (meters) x,y,z
                                                              2 0 0 0
         1 Node ID, Node coord. (meters) x,y,z
 49 BO
50 BO
                                                             3 0 0 3188.8
         1 Node ID, Node coord. (meters) x,y,z
                                                              4 0 0 -3188.8
 51 BO 1 Node ID, Node coord. (meters) x,y,z
 52 BO 1 Node ID, Node structual joint ID
```

```
2
         2 Body ID number
 53 BO
         2 Type (Rigid, Flexible, NASTRAN)
 54 BO
 55 BO 2 Number of modes
 56 BO 2 Modal calculation option (0, 1 or 2)
         2 Foreshortening option (Y/N)
 58 BO 2 Model reduction method (NO,MS,MC,CC,QM,CV)
 59 BO 2 NASTRAN data file FORTRAN unit number (40 - 60)
         2 Number of augmented nodes (0 if none)
 60 BO
         2 Damping matrix option (NS,CD,HL,SD)
 61 BO
         2 Constant damping ratio
 62 BO
         2 Low frequency, High frequency ratios
 63 BO
         2 Mode ID number, damping ratio
 64 BO
         2 Conversion factors: Length, Mass, Force
 65 BO
 66 BO 2 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
                                                        .8543E12 1.5601E12
         2 Moments of inertia (kg-m2) Ixx,Iyy,Izz
 67 BO
1.3822E12
                                                                 0 0 0
 68 BO 2 Products of inertia (kg-m2) Ixy,Ixz,Iyz
                                                                  12666300
        2 Mass (kg)
        2 Number of Nodes
 69 BO
 70 BO
                                                                  1 298.323 0 0
          2 Node ID, Node coord. (meters) x,y,z
  71 BO
         2 Node ID, Node coord. (meters) x,y,z
                                                                 2000
 72 BO
                                                                 3 0 0 300
          2 Node ID, Node coord. (meters) x,y,z
  73 BO
                                                                  4 0 0 -300
          2 Node ID, Node coord. (meters) x,y,z
  74 BO
                                                                  5 500 0 0
          2 Node ID, Node coord. (meters) x,y,z
  75 BO
         2 Node ID, Node structual joint ID
  76 BO
                                                                  3
          3 Body ID number
  77 BO
                                                                  R
         3 Type (Rigid, Flexible, NASTRAN)
  78 BO
         3 Number of modes
         3 Modal calculation option (0, 1 or 2)
  80 BO
          3 Foreshortening option (Y/N)
  81 BO
         3 Model reduction method (NO,MS,MC,CC,QM,CV)
  82 BO
         3 NASTRAN data file FORTRAN unit number (40 - 60)
  83 BO
          3 Number of augmented nodes (0 if none)
  84 BO
         3 Damping matrix option (NS,CD,HL,SD)
  85 BO
         3 Constant damping ratio
         3 Low frequency, High frequency ratios
  87 BO
          3 Mode ID number, damping ratio
  88 BO
         3 Conversion factors: Length, Mass, Force
  89 BO
         3 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
         3 Moments of inertia (kg-m2) Ixx,Iyy,Izz 1.7E12 1.7E12 3.4E12 3 Products of inertia (kg-m2) Ixy,Ixz,Iyz 0 0 0
  90 BO
  91 BO
  92 BO
                                                                 2046600
         3 Mass (kg)
  93 BO
         3 Number of Nodes
  94 BO
                                                                  1 0 0 0
          3 Node ID, Node coord. (meters) x,y,z
  95 BO
                                                                  2 0 0 0
         3 Node ID, Node coord. (meters) x,y,z
  96 BO
        3 Node ID, Node structual joint ID
  97 BO
                                                                   4
         4 Body ID number
  98 BO
                                                                   R
  99 BO 4 Type (Rigid, Flexible, NASTRAN)
 100 BO 4 Number of modes
101 BO 4 Modal calculation option (0, 1 or 2)
 102 BO 4 Foreshortening option (Y/N)
         4 Model reduction method (NO,MS,MC,CC,QM,CV)
 103 BO
 104 BO 4 NASTRAN data file FORTRAN unit number (40 - 60)
105 BO 4 Number of augmented nodes (0 if none)
 106 BO 4 Damping matrix option (NS,CD,HL,SD)
         4 Constant damping ratio
4 Low frequency, High frequency ratios
 107 BO
 108 BO
         4 Mode ID number, damping ratio
 109 BO
         4 Conversion factors: Length, Mass, Force
 110 BO
         4 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
4 Moments of inertia (kg-m2) Ixx, Iyy, Izz 1.7E12 1.7E12 3.4E12
  111 BO
  112 BO
                                                                  0 0 0
  113 BO 4 Products of inertia (kg-m2) Ixy,Ixz,Iyz
         4 Mass (kg)
                                                                   2046600
  114 BO
          4 Number of Nodes
  115 BO
                                                                  1 0 0 0
  116 BO 4 Node ID, Node coord. (meters) x,y,z
  117 BO 4 Node ID, Node coord. (meters) x,y,z
118 BO 4 Node ID, Node structual joint ID
                                                                   2 0 0 0
```

Bd Systems® TCD20000222A 29 December 2000 HINGE

110 UT	1 Hinge ID number	1
119 HI 120 HI	1 Inboard body ID, Outboard body ID	0 1
121 HI	1 "-" made ID "a" node ID	0 2
122 HI	1 Number of rotation DOFs, Rotation option (F of G)	3 F 1 0 0
123 HI	1 II unit vector in inboard body coold. A, y, 2	1 0 0
124 HI	1 11 unit vector in outboard body coold. X, Y, 2	1 0 0
125 HI	1 12 unit vector in inboard body could, X,Y,2	
126 HI	1 L2 unit vector in outboard body coord. x,y,z	0 0 1
127 HI	1 L3 unit vector in inboard body coord. x,y,z	0 0 1
128 HI	1 L3 unit vector in outboard body coord. x,y,z	-90 0 90
129 HI	1 Initial rotation angles (deg) 1 Initial rotation rates (deg/sec)	0 0 0.00417807
130 HI	1 Rotation stiffness (newton-meters/rad)	0 0 0
131 HI	1 Rotation damping (newton-meters/rad/sec)	0 0 0
132 HI	1 Null torque angles (deg)	0 0 0
133 HI 134 HI	1 Number of translation DOFs	3
135 HI	1 First translation unit vector gl	1 0 0
136 HI	1 Second translation unit vector g2	0 1 0 0 0 1
137 HI	1 Third translation unit vector 93	0 0 1
138 HI	1 Initial translation (meters)	3074.681 0 0
139 HI	1 Initial translation velocity (meters/sec)	0 0 0
140 HI	1 Translation stiffness (newtons/meters)	0 0 0
141 HI	1 Translation damping (newtons/meter/sec)	0 0 0
142 HI	1 Null force translations	
442 117	2 Hinge ID number	2
143 HI	2 Inboard body ID, Outboard body ID	1 2
144 HI 145 HI	2 "p" node ID, "q" node ID	2 2
146 HI	2 Number of rotation DOFS	0
147 HI	2 11 unit vector in inboard body coord. X,Y,Z	0 0 1 0 0 1
148 HI	2 Il unit vector in outboard body coord, X,y,2	0 0 1
149 HI	a to unit vector in inboard body coord, X,Y,2	
150 HI	2 L2 unit vector in outboard body coord. x,y,z	1 0 0
151 HI	2 L3 unit vector in inboard body coord. x,y,z 2 L3 unit vector in outboard body coord. x,y,z	1 0 0
152 HI	2 Initial rotation angles (deg)	0 0 0
153 HI	2 Initial rotation rates (deg/sec)	
154 HI 155 HI	2 Potation stiffness (newton-meters/rad)	
156 HI	2 Rotation damping (newton-meters/rad/sec)	
150 HI	2 Null torque angles (deg)	^
158 HI	2 Number of translation DOFs	0 1 0 0
159 HI	2 First translation unit vector g1	0 1 0
160 HI	2 Second translation unit vector g2	0 0 1
161 HI		0 0 0
162 HI	2 Initial translation (meters) 2 Initial translation velocity (meters/sec)	
163 HI	2 Translation stiffness (newtons/meters)	
164 HI	2 Translation damping (newtons/meter/sec)	
165 HI 166 HI	2 Null force translations	
100 111		3
167 HI	3 Hinge ID number	1 3
168 HI	3 Inboard body ID, Outboard body ID	3 2
169 HI	3 "p" node ID, "q" node ID 3 Number of rotation DOFs	2
170 HI	3 Number of rotation bors 3 L1 unit vector in inboard body coord. x,y,z	0 0 1
171 HI	3 L1 unit vector in outboard body coord. x,y,z	0 0 1
172 HI	a to unit vector in inheard body coord, X,Y,Z	1 0 0
173 HI 174 HI	2 12 unit vector in outboard body coord, X,Y,Z	1 0 0
175 HI	2 12 unit wester in inheard body coord, X,Y,Z	
176 HI	3 13 unit vector in outboard body coord. x,y,z	0. 123.25 0.
177 HI	3 Initial rotation angles (deg)	004178 0
178 HI	3 Initial rotation rates (deg/sec)	0 0
179 HI	3 Rotation stiffness (newton-meters/rad) 3 Rotation damping (newton-meters/rad/sec)	0 0
180 HI	3 Null torque angles (deg)	0 0
181 HI	3 Null torque angles (deg) 3 Number of translation DOFs	0
182 HI 183 HI	3 First translation unit vector gl	1 0 0
184 HI	3 Second translation unit vector g2	0 1 0
101 111		

```
Contract No.
Bd Systems®
                                                                                     NAS8-00151
TCD20000222A
                                                                                      Final Report
29 December 2000
                                                                    0 0 1
         3 Third translation unit vector
 185 HI
                                                                    0 0 0
          3 Initial translation (meters)
         3 Initial translation velocity (meters/sec)
 187 HI
         3 Translation stiffness (newtons/meters)
 189 HI 3 Translation damping (newtons/meter/sec)
190 HI 3 Null force translations
                                                                    4
           4 Hinge ID number
           4 Inboard body ID, Outboard body ID
 192 HI
                                                                    4 2
           4 "p" node ID, "q" node ID
 193 HI
           4 Number of rotation DOFs
 194 HI
        4 L1 unit vector in inboard body coord. x,y,z
                                                                    0 0 1
 195 HI
 196 HI 4 L1 unit vector in outboard body coord. x,y,z
197 HI 4 L2 unit vector in inboard body coord. x,y,z
                                                                    0 0 1
                                                                    1 0 0
                                                                    1 0 0
 198 HI 4 L2 unit vector in outboard body coord. x,y,z
 199 HI 4 L3 unit vector in inboard body coord. x,y,z
           4 L3 unit vector in outboard body coord. x,y,z
 200 HI
                                                                    0. 33.25 0.
 201 HI 4 Initial rotation angles (deg)
                                                                    -.004178 0
 202 HI 4 Initial rotation rates (deg/sec)
 203 HI 4 Rotation stiffness (newton-meters/rad)
204 HI 4 Rotation damping (newton-meters/rad/sec)
205 HI 4 Null torque angles (deg)
                                                                    0.0
                                                                    0
  206 HI 4 Number of translation DOFs
                                                                    1 0 0
 207 HI 4 First translation unit vector g1
208 HI 4 Second translation unit vector g2
                                                                    0 1 0
                                                                    0 0 1
  209 HI 4 Third translation unit vector g3
                                                                    0 0 0
  210 HI 4 Initial translation (meters)
          4 Initial translation velocity (meters/sec)
  211 HI
  212 HI 4 Translation stiffness (newtons/meters)
  213 HI 4 Translation damping (newtons/meter/sec)
          4 Null force translations
  214 HI
             SENSOR
          1 Sensor ID number
  215 SE
  216 SE 1 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ET
  217 SE 1 Mounting point body ID, Mounting point node ID
           1 Second mounting point body ID, Second node ID
  218 SE
          1 Input axis unit vector (IA) x,y,z
  219 SE
          1 Mounting point Hinge index, Axis index
  220 SE
          1 First focal plane unit vector (Fp1) x,y,z
1 Second focal plane unit vector (Fp2) x,y,z
                                                                     0 0 -1
  221 SE
                                                                     0 1 0
  222 SE
  223 SE 1 Sun/Star unit vector (Us) x,y,z
          1 Velocity Aberration Option (Y/N)
  224 SE
           1 Euler Angle Sequence (1-6)
  225 SE
          1 CMG ID number and Gimbal number
  226 SE
                                                                     6378000 0 0 4.178074D-3
          1 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
  227 SE
  228 SE 2 Sensor ID number
  229 SE 2 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST
  230 SE 2 Mounting point body ID, Mounting point node ID
            2 Second mounting point body ID, Second node ID
  231 SE
  232 SE 2 Input axis unit vector (IA) x,y,z
  233 SE 2 Mounting point Hinge index, Axis index
          2 First focal plane unit vector (Fp1) x,y,z
2 Second focal plane unit vector (Fp2) x,y,z
                                                                     0 -1 0
  234 SE
                                                                     1 0 0
  235 SE
                                                                     0 1 0
           2 Sun/Star unit vector (Us) x,y,z
  236 SE
           2 Velocity Aberration Option (Y/N)
  237 SE
            2 Euler Angle Sequence (1-6)
  238 SE
           2 CMG ID number and Gimbal number
  239 SE
  240 SE 2 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
            3 Sensor ID number
  241 SE
  242 SE 3 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) L
            3 Mounting point body ID, Mounting point node ID
   243 SE
            3 Second mounting point body ID, Second node ID
   244 SE
                                                                      1 2 3
            3 Input axis unit vector (IA) x,y,z
   245 SE
            3 Mounting point Hinge index, Axis index
   246 SE
            3 First focal plane unit vector (Fp1) x,y,z
   247 SE
            3 Second focal plane unit vector (Fp2) x,y,z
   248 SE
```

Bd Systems® TCD20000222A 29 December 2000 3 Sun/Star unit vector (Us) x,y,z 249 SE 3 Velocity Aberration Option (Y/N)250 SE 3 Euler Angle Sequence (1-6) 251 SE $252~{
m SE}$ 3 CMG ID number and Gimbal number 253 SE 3 Earth pt (rad,lat,lon,rotation [m/e, d, d, d/s]) 4 Sensor ID number 254 SE 4 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) L 4 Mounting point body ID, Mounting point node ID 256 SE 4 Second mounting point body ID, Second node ID 257 SE 3 2 1 4 Input axis unit vector (IA) x,y,z 258 SE 4 Mounting point Hinge index, Axis index 259 SE 4 First focal plane unit vector (Fp1) x,y,z 260 SE 4 Second focal plane unit vector (Fp2) x,y,z 261 SE 262 SE 4 Sun/Star unit vector (Us) x,y,z 263 SE 4 Velocity Aberration Option (Y/N) 4 Euler Angle Sequence (1-6) 264 SE 4 CMG ID number and Gimbal number 265 SE 266 SE 4 Earth pt (rad,lat,lon,rotation [m/e, d, d, d/s]) 5 Sensor ID number 267 SE 5 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST 268 SE 5 Mounting point body ID, Mounting point node ID 5 Second mounting point body ID, Second node ID 270 SE 5 Input axis unit vector (IA) x,y,z 271 SE 5 Mounting point Hinge index, Axis index 272 SE 5 First focal plane unit vector (Fp1) x,y,z 0 0 1 273 SE 0 -1 0 5 Second focal plane unit vector (Fp2) x,y,z274 SE 0 0 0 5 Sun/Star unit vector (Us) x,y,z 275 SE N 5 Velocity Aberration Option (Y/N)276 SE 5 Euler Angle Sequence (1-6) 277 SE 5 CMG ID number and Gimbal number 278 SE 5 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 279 SE 6 Sensor ID number 280 SE 6 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV A3 281 SE 6 Mounting point body ID, Mounting point node ID 282 SE 6 Second mounting point body ID, Second node ID 283 SE 6 Input axis unit vector (IA) x,y,z 284 SE 6 Mounting point Hinge index, Axis index 285 SE 6 First focal plane unit vector (Fp1) x,y,z 286 SE 6 Second focal plane unit vector (Fp2) x,y,z 6 Sun/Star unit vector (Us) x,y,z 287 SE 288 SE 6 Velocity Aberration Option (Y/N) 289 SE 6 Euler Angle Sequence (1-6) 290 SE 6 CMG ID number and Gimbal number 291 SE 6 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 292 SE ACTR 1 Actuator ID number 293 AC 1 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) MO 294 AC 1 Actuator location; Node or Hinge (N or H) 295 AC 1 Mounting point body ID number, node ID number 2 2 296 AC 1 Second mounting point body ID, second node ID 297 AC 0 1 0 1 Output axis unit vector x,y,z 298 AC 1 Mounting point Hinge index, Axis index 299 AC 1 Rotor spin axis unit vector x,y,z 300 AC 1 Initial rotor momentum, H 301 AC 1 Outer gimbal- angle(deg), inertia, friction(D,S,B,N) 302 AC 1 Outer gimbal axis unit vector x,y,z 303 AC 1 Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 304 AC 1 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 305 AC 1 Inner gimbal axis unit vector x,y,z306 AC 1 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 307 AC 1 Initial length and rate, y(to) and ydot(to) 308 AC 1 Constants; K1 or wo, n or zeta, Kg, Jm 309 AC 1 Non-linearities; TLim, Tco, Dz 310 AC 2

Contract No.

NAS8-00151

Final Report

2 Actuator ID number

311 AC

Bd Systems® TCD20000222A

Contract No. NAS8-00151 Final Report

29 December 2000 MO 2 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 2 Actuator location; Node or Hinge (N or H) 2 2 2 Mounting point body ID number, node ID number 2 Second mounting point body ID, second node ID 315 AC 0 0 1 2 Output axis unit vector x,y,z 316 AC 2 Mounting point Hinge index, Axis index 317 AC 2 Rotor spin axis unit vector x,y,z 318 AC 2 Initial rotor momentum, H 319 AC 2 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 320 AC 2 Outer gimbal axis unit vector x,y,z321 AC 2 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 322 AC 2 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 323 AC 2 Inner gimbal axis unit vector x,y,z 324 AC 2 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 325 AC 2 Initial length and rate, y(to) and ydot(to) 326 AC 2 Constants; K1 or wo, n or zeta, Kg, Jm 327 AC 2 Non-linearities; TLim, Tco, Dz 328 AC 3 3 Actuator ID number 329 AC MO 3 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 3 Actuator location; Node or Hinge (N or H) 331 AC 3 Mounting point body ID number, node ID number 332 AC 3 Second mounting point body ID, second node ID 333 AC 1 0 0 3 Output axis unit vector x,y,z 334 AC 3 Mounting point Hinge index, Axis index 335 AC 3 Rotor spin axis unit vector x,y,z 336 AC 3 Initial rotor momentum, H 337 AC 3 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 338 AC 3 Outer gimbal axis unit vector x,y,z 339 AC 3 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 340 AC 3 Inner gimbal- angle(deg),inertia,friction(D,S,B,N)
3 Inner gimbal axis unit vector x,y,z 341 AC 342 AC 3 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 343 AC 3 Initial length and rate, y(to) and ydot(to) 344 AC 3 Constants; K1 or wo, n or zeta, Kg, Jm 345 AC 3 Non-linearities; TLim, Tco, Dz 346 AC 4 Actuator ID number 347 AC MO 4 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 348 AC 4 Actuator location; Node or Hinge (N or H) 349 AC 4 Mounting point body ID number, node ID number 3 2 350 AC 4 Second mounting point body ID, second node ID 351 AC 1 0 0 4 Output axis unit vector x,y,z 352 AC 4 Mounting point Hinge index, Axis index 353 AC 4 Rotor spin axis unit vector x,y,z 354 AC 4 Initial rotor momentum, H 355 AC 4 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 356 AC 4 Outer gimbal axis unit vector x,y,z 357 AC 4 Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 358 AC 4 Inner gimbal- angle(deg), inertia, friction(D,S,B,N) 359 AC 4 Inner gimbal axis unit vector x,y,z 360 AC 4 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 361 AC 4 Initial length and rate, y(to) and ydot(to) 362 AC 4 Constants; K1 or wo, n or zeta, Kg, Jm 363 AC 4 Non-linearities; TLim, Tco, Dz 364 AC 5 Actuator ID number 365 AC MO 5 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 366 AC 5 Actuator location; Node or Hinge (N or H) 367 AC 5 Mounting point body ID number, node ID number 3 2 368 AC 5 Second mounting point body ID, second node ID 369 AC 0 1 0 5 Output axis unit vector x,y,z 370 AC 5 Mounting point Hinge index, Axis index 371 AC 5 Rotor spin axis unit vector x,y,z 372 AC 5 Initial rotor momentum, H 373 AC 5 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 374 AC 5 Outer gimbal axis unit vector x,y,z375 AC 5 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 376 AC 5 Inner gimbal- angle(deg), inertia, friction(D,S,B,N) 377 AC 5 Inner gimbal axis unit vector x,y,z 378 AC 5 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)

Bd Systems® TCD20000222A 29 December 2000 5 Initial length and rate, y(to) and ydot(to) 380 AC 5 Constants; K1 or wo, n or zeta, Kg, Jm 5 Non-linearities; TLim, Tco, Dz 382 AC 6 6 Actuator ID number 383 AC MO 6 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 384 AC 6 Actuator location; Node or Hinge (N or H) 385 AC 4 2 6 Mounting point body ID number, node ID number 386 AC 6 Second mounting point body ID, second node ID 387 AC 1 0 0 6 Output axis unit vector x,y,z 388 AC 6 Mounting point Hinge index, Axis index 389 AC 6 Rotor spin axis unit vector x,y,z 390 AC 6 Initial rotor momentum, H 391 AC 6 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 392 AC 6 Outer gimbal axis unit vector x,y,z 393 AC 6 Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 394 AC 6 Inner gimbal- angle(deg), inertia, friction(D,S,B,N) 395 AC 6 Inner gimbal axis unit vector x,y,z396 AC 6 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 397 AC 6 Initial length and rate, y(to) and ydot(to) 398 AC 6 Constants; K1 or wo, n or zeta, Kg, Jm 399 AC 6 Non-linearities; TLim, Tco, Dz 400 AC 7 Actuator ID number 401 AC 7 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) MO 402 AC 7 Actuator location; Node or Hinge (N or H) 403 AC 7 Mounting point body ID number, node ID number 4 2 404 AC 7 Second mounting point body ID, second node ID 405 AC 0 1 0 7 Output axis unit vector x,y,z 406 AC 7 Mounting point Hinge index, Axis index 407 AC 7 Rotor spin axis unit vector x,y,z408 AC 7 Initial rotor momentum, H 409 AC 7 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 410 AC 7 Outer gimbal axis unit vector x,y,z411 AC 7 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 412 AC 7 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 413 AC 7 Inner gimbal axis unit vector x,y,z 414 AC 7 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 415 AC 7 Initial length and rate, y(to) and ydot(to) 416 AC 7 Constants; K1 or wo, n or zeta, Kg, Jm 417 AC 7 Non-linearities; TLim, Tco, Dz 418 AC 8 Actuator ID number 419 AC J 8 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 420 AC 8 Actuator location; Node or Hinge (N or H) 421 AC 8 Mounting point body ID number, node ID number 2 5 422 AC 8 Second mounting point body ID, second node ID 423 AC -1 0 0 8 Output axis unit vector x,y,z 424 AC 8 Mounting point Hinge index, Axis index 425 AC 8 Rotor spin axis unit vector x,y,z 426 AC 8 Initial rotor momentum, H 427 AC 8 Outer gimbal- angle(deg), inertia, friction(D,S,B,N)428 AC 8 Outer gimbal axis unit vector x,y,z429 AC 8 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 430 AC 8 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 431 AC 8 Inner gimbal axis unit vector x,y,z432 AC 8 In gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k)433 AC 8 Initial length and rate, y(to) and ydot(to) 434 AC 8 Constants; K1 or wo, n or zeta, Kg, Jm 435 AC 8 Non-linearities; TLim, Tco, Dz 436 AC CONTROLLER 1 Controller ID number 437 CO 1 Controller type (CB,CM,DB,DM,UC,UD) CM 438 CO 1 Sample time (sec) 439 CO 7 7 1 Number of inputs, Number of outputs 440 CO 1 Number of states 1 Output No., Input type (I,S,T), Input ID, Gain 441 CO

Contract No.

NAS8-00151

Final Report

Contract No. NAS8-00151 Final Report

Bd Systems® TCD20000222A 29 December 2000 INTERCONNECT

443 IN 444 IN 445 IN 446 IN	<pre>1 Interconnect ID number 1 Source type(S,C, or F),Source ID,Source row # 1 Destination type(A or C),Dest ID,Dest row # 1 Gain</pre>	1 S 1 1 C 1 1 4.41E13
447 IN 448 IN 449 IN 450 IN	<pre>2 Interconnect ID number 2 Source type(S,C, or F),Source ID,Source row # 2 Destination type(A or C),Dest ID,Dest row # 2 Gain</pre>	2 C 1 1 A 1 1 1.
451 IN 452 IN 453 IN 454 IN	<pre>3 Interconnect ID number 3 Source type(S,C, or F),Source ID,Source row # 3 Destination type(A or C),Dest ID,Dest row # 3 Gain</pre>	3 S 1 2 C 1 2 1.67E12
455 IN 456 IN 457 IN 458 IN	4 Interconnect ID number 4 Source type(S,C, or F),Source ID,Source row # 4 Destination type(A or C),Dest ID,Dest row # 4 Gain	4 C 1 2 A 2 1 1
459 IN 460 IN 461 IN 462 IN	<pre>5 Interconnect ID number 5 Source type(S,C, or F),Source ID,Source row # 5 Destination type(A or C),Dest ID,Dest row # 5 Gain</pre>	5 S 2 1 C 1 3 4.31E13
463 IN 464 IN 465 IN 466 IN	<pre>6 Interconnect ID number 6 Source type(S,C, or F),Source ID,Source row # 6 Destination type(A or C),Dest ID,Dest row # 6 Gain</pre>	6 C 1 3 A 3 1
467 IN 468 IN 469 IN 470 IN	<pre>7 Interconnect ID number 7 Source type(S,C, or F),Source ID,Source row # 7 Destination type(A or C),Dest ID,Dest row # 7 Gain</pre>	7 S 3 1 C 1 4 1.7E12
471 IN 472 IN 473 IN 474 IN	<pre>8 Interconnect ID number 8 Source type(S,C, or F),Source ID,Source row # 8 Destination type(A or C),Dest ID,Dest row # 8 Gain</pre>	8 C 1 4 A 4 1 1
475 IN 476 IN 477 IN 478 IN	<pre>9 Interconnect ID number 9 Source type(S,C, or F),Source ID,Source row # 9 Destination type(A or C),Dest ID,Dest row # 9 Gain</pre>	9 s 3 2 C 1 5 1.7E12
479 IN 480 IN 481 IN 482 IN	10 Interconnect ID number 10 Source type(S,C, or F),Source ID,Source row # 10 Destination type(A or C),Dest ID,Dest row # 10 Gain	10 C 1 5 A 5 1 1
483 IN 484 IN 485 IN 486 IN	<pre>11 Interconnect ID number 11 Source type(S,C, or F),Source ID,Source row # 11 Destination type(A or C),Dest ID,Dest row # 11 Gain</pre>	11 S 4 1 C 1 6 1.7E12
487 IN 488 IN 489 IN 490 IN	12 Interconnect ID number 12 Source type(S,C, or F),Source ID,Source row # 12 Destination type(A or C),Dest ID,Dest row # 12 Gain	12 C 1 6 A 6 1 1
491 IN 492 IN 493 IN 494 IN	13 Destination type(A or C), Dest 1D, Dest 10w #	13 S 4 2 C 1 7 1.7E12
495 IN 496 IN 497 IN	14 Interconnect ID number 14 Source type(S,C, or F), Source ID, Source row #	14 C 1 7 A 7 1

Bd Systems® TCD20000222A 29 December 2000 498 IN 14 Gain 1 499 IN 15 Interconnect ID number 500 IN 15 Source type(S,C, or F), Source ID, Source row # S 5 3 A 8 1 7.0 502 IN 15 Gain 15 Gain

isc3_flex_sol.lin (Concept 2B) Summer Solstice

```
* Controller for integrated symmetrical concentrator
system CONT1 14,7,7,0,0,0.0
0 1 0 0 0 0 0 0 0 0 0 0 0 0
-1 -1.4 0 0 0 0 0 0 0 0 0 0 0 0
0 \ 0 \ -1 \ -1.4 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0
\begin{smallmatrix} 0 & 0 & 0 & 0 & -1 & -1 & .4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{smallmatrix}
0 0 0 0 0 0 -1 -1.4 0 0 0 0 0
0 0 0 0 0 0 0 0 -1 -1.4 0 0 0 0
0 0 0 0 0 0 0 0 0 0 -1 -1.4 0 0
*B
0 0 0 0 0 0 0
1 0 0 0 0 0 0
0 0 0 0 0 0 0
0 1 0 0 0 0 0
0 0 0 0 0 0 0
0 0 1 0 0 0 0
0 0 0 0 0 0 0
0 0 0 1 0 0 0
0 0 0 0 0 0 0
0 0 0 0 1 0 0
0 0 0 0 0 0 0
0 0 0 0 0 1 0
0 0 0 0 0 0 0
0 0 0 0 0 0 1
 .000025 .007 0 0 0 0 0 0 0 0 0 0 0 0
0 0 .000025 .007 0 0 0 0 0 0 0 0 0 0
0 0 0 0 .000025 .007 0 0 0 0 0 0 0 0
\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & .0001 & .014 & 0 & 0 & 0 & 0 & 0 \end{smallmatrix}
0 0 0 0 0 0 0 0 0 0 0 .0001 .014 0 0
0 0 0 0 0 0 0 0 0 0 0 0 .0001 .014
 *D
0 0 0 0 0 0 0
 0 0 0 0 0 0 0
 0 0 0 0 0 0 0
 0 0 0 0 0 0 0
 0 0 0 0 0 0 0
 0 0 0 0 0 0 0
 0 \ 0 \ 0 \ 0 \ 0 \ 0
 * H
 *M
```

29 December 2000

los.dat (Concept 2B) Summer Solstice

```
3,
0.d0,0.d0,0.d0,
0.d0,0.d0,
0.d0,-1.d0,0.d0,
1 Target star along negative polar axis
0.d0,-1.d0,0.d0,
1 Focal plane vector 1
1.d0,0.d0,0.d0,
1 Sensor number of 2nd FGS (clamshell) sensor
0.d0,0.d0,0.d0,
1 Target star along positive polar axis
0.d0,0.d0,0.d0,
1 Focal plane vector 3
1.d0,0.d0,0.d0,
1 Target star along positive polar axis
0.d0,-1.d0,0.d0,
1 Focal plane vector 1
1.d0,0.d0,0.d0,
1 Focal plane vector 2
1.d0,0.d0,0.d0,
1 Focal plane vector 3
1.d0,0.d0,0.d0,
1 Focal plane vector 3
```

solar pressure.dat (Concept 2B) Summer Solstice

12, 'm', 1 number of panels, units English or Metric ***Updated 11/15/00*** 2. 538000. d0, 0.60, 0.60, 0.60, 0.60, 0.60, 2. 538000. d0, 0.560, 1.60, 0.60
22, 'm', inumber of panels, u. 1, 2,638000.d0,0.5d0,1.d0,0.d0,0.d0,0.d0,0.d0,0.d0,0.d0,0.

isc3_flex_sol.flx (Concept 2B) Summer Solstice (An Excerpt)

```
flag, revision number
                   1
XXXXXX
  body id
        1
  modes, nodes, modal options
                                                                             0
                                      0
                            0
       24
                                                                             0
                                                                   0
                                               0
                            0
                                      0
                  n
        0
                                                                   0
                                                                             0
                                                          0
                                                0
                                      0
                  0
                            0
        Ω
                                                                             0
                                                                   0
                                               0
                                                          0
                                      0
                            0
        0
                  0
                                  2
  phi_t for node #
                                                                            .31346273E-02
  .31310941E-02 -.16357954E-03 .19158607E-08 .68659216E-04
   .14949358E-08 -.33409338E-09 -.17910070E-08 -.62130721E-04
                                                                            .10048928E-08
   .74260327E-10 -.81693812E-09 .66744219E-10 -.57300403E-09
                                                                           .56292416E-10
 -.31109642E-09 .51999889E-08 .41569313E-10 .36697769E-02 .69502051E-03 .85567197E-10 -.10557893E-02 .35826871E-02 .65924560E-10 .61553749E-10 .11085623E-08 -.67301328E-05 .49549244E-10 -.49437998E-08 -.60865848E-11 .10484816E-08 .39239830E-10 -.17858973E-09 .46440350E-10 .23145265E-09 .17858973E-09 .46440350E-10 .23145265E-09
   .76239104E-11 -.98486197E-09 -.52382674E-09 .30708566E-12 .12143532E-10
 -.10722701E-09 .94529479E-03 .17735129E-08 .15323995E-09 .13868812E-12
  -.13390485E-02 -.55272105E-04 -.82202021E-12 .55317399E-04 -.13390483E-02
   .27552836E-11 .29149021E-10 -.27567962E-12 -.44865972E-10 .48584658E-11
   .10595799E-10 -.31919479E-08 -.19937738E-10 .14255509E-09 -.23770452E-02
 -.45933446E-03 -.19673179E-04 .63985161E-12 -.19675549E-04 .45933391E-03 
-.74265281E-12 -.34874105E-11 -.12587102E-11 .59687765E-09 -.12099360E-11
  -.69004494E-11 .19524343E-08
   phi_t prime for node #
   .17177767E-11 -.22808543E-11 -.45683561E-10 .19817016E-10 .56718933E-12
   .31514104E-09 .17463000E-11 -.27057756E-13 -.60467460E-12 .11400599E-06
  -.42543750E-05 -.11919737E-10 .42546793E-05 .10153760E-06 -.34352434E-10
   .41859459E-11 -.37080794E-11 .59234151E-04 .45504345E-11 -.70844966E-12
   .15588470E-10 .13593377E-10 .68741697E-12 .87795145E-10 -.28497036E-11 .31909564E-13 -.69421743E-15 .38765922E-11 -.41335440E-11 -.44983453E-04 .22473012E-05 -.13022411E-04 .41075666E-11 -.13101519E-04 -.17274113E-05
  -.98017672E-11 -.14778531E-12 -.42275125E-13 -.96071643E-06 -.25440820E-11 .54200130E-11 .41425181E-12 -.51084189E-13 .98880082E-15 .14899414E-06
  -.49351318E-14 .15066380E-14 -.42969795E-10 -.54223125E-14 .27635772E-15
  -.79851673E-11 .23444071E-06 -.40722409E-05 -.13017710E-13 .40722809E-05
    .17482812E-05 .30019490E-13 -.17482739E-05
    .22611633E-11 -.61243211E-07
   -.61449314E-07 -.27684414E-12
                                   3
   phi_t for node #
                                        .19835813E-08 -.36612814E-03 -.42534660E-02
   -.42404714E-02 .49480955E-03
                                        .30963712E-08 .40516924E-04 .38549281E-02
    .96750031E-09 .42209027E-09
   -.52714285E-03 -.87737477E-09
   .88009461E-09 .18408168E-03 -.17813513E-08 -.27431844E-08 .15957166E-04 -.19242852E-02 .34087019E-03 -.22330623E-09 .41716037E-03 .19091971E-02
   -.71605887E-10 .95016675E-09 -.81490514E-09 .32861442E-02 -.18116747E-08
    .55541036E-09 .79551900E-03 -.41608643E-08 -.26069981E-09 .94036451E-02
   .21682867E-02 -.12127210E-02 .85710915E-08 .12126479E-02 .21683282E-02 -.39141685E-08 .18971552E-02 -.12009168E-02 .43705940E-08 .12012029E-02
    .18969745E-02 .16937062E-07 -.67726532E-08 -.66549206E-08 .11440634E-01
     .49982895E-02 -.24804966E-02 .39527267E-09 -.24804686E-02 -.49983050E-02
                                         .25440974E-02 -.23331468E-08 -.25435047E-02
   -.34622476E-08 -.50056020E-02
   -.50059046E-02 -.85708461E-08
    phi_t prime for node #
   -.50525028E-06 -.31564387E-05 -.80521842E-10 .31702786E-05 -.40940183E-06
    .57389171E-09 -.26678138E-11 .65900274E-12 -.58046889E-04 .10244708E-05 .47674564E-05 .15531760E-10 -.47644389E-05 .10384376E-05 .4257276E-10
                     .49389619E-11 -.61429724E-04 .68382965E-06
   -.20073106E-10 -.54985919E-05 .13880871E-06 -.11950858E-09 -.12906028E-11 .35486701E-12 -.77274292E-04 .61171041E-11 -.56114520E-11 -.65377923E-04 .24079039E-11 -.54062017E-05 .19338345E-05
     .41797610E-11 .67570000E-11 .20000043E-10 .51675836E-06 -.99163146E-11
    -.24536147E-10 .16113741E-05 -.24387637E-10 -.45291231E-10 .14474359E-04
                      .55846277E-04 -.22605263E-10 -.55847708E-04 .40549096E-04
     .40550997E-04
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Bd Systems® TCD20000222A

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29 December 2000
                                                 .40806300E-04 .51925447E-04 -.22326921E-10 -.51919351E-04
   -.12064872E-11
                                                .35521932E-10 .15828591E-09 -.16771401E-09 .21209458E-04
      .16987298E-03 .27619447E-03 .11975439E-09 .27619558E-03 -.16987148E-03
   -.57982074E-10 -.17376694E-03 -.27781790E-03 -.11765510E-09 .27783862E-03
   -.17373409E-03 -.70075300E-10
     phi_t for node #
                                                                                             .18585028E-08 -.36612933E-03 -.42535396E-02
    -.42404802E-02 .49480360E-03
      .21036956E-08 .39723035E-09 -.14786269E-09 .40516905E-04 -.38549306E-02
       .52714303E-03 -.77214743E-09 -.53843745E-03 -.38533660E-02 .20798890E-09
    -.73886299E-08 -.15978809E-07 -.24131650E-03 .31427093E-02 -.10270436E-03 .13801450E-10 -.20968938E-03 .31373931E-02 -.39914612E-09 .41931685E-11 .99616139E-10 .18408168E-03 .35438059E-09 -.17390277E-08 -.15957178E-04
       .19242857E-02 -.34087031E-03 -.23866856E-09 -.41716036E-03 -.19091972E-02
    -.19395891E-10 .94356214E-09 -.84924469E-09 -.32861442E-02 .18078300E-08
    -.56604075E-09 .79551900E-03 -.41738415E-08 -.28114281E-09 -.94036451E-02
       .21682868E-02 -.12127209E-02 -.85410786E-08 .12126480E-02 .21683284E-02
     .38256346E-08 -.18971552E-02 .12009169E-02 .43704936E-08 -.12012030E-02 
-.18969746E-02 .17005110E-07 .67789071E-08 .66775796E-08 .11440634E-01
       .49982897E-02 -.24804968E-02 -.39492666E-09 -.24804688E-02 -.49983053E-02
       .34827434E-08 .50056020E-02 -.25440973E-02 -.23324836E-08 .25435049E-02
        .50059050E-02 -.85841247E-08
                                                                                                      4
       .50524725E-06 .31564441E-05 -.82070494E-10 -.31703213E-05 .40940604E-06
.62154334E-09 .34011412E-12 -.27858908E-12 .58046878E-04 .10244712E-05
.47674599E-05 .13355611E-10 -.47644372E-05 .10384375E-05 .44054122E-10
       phi_t prime for node #
     -.22077045E-10 .11247290E-10 -.61429722E-04 -.68382100E-06 -.54576879E-05
    -.24464605E-10 -.16113739E-05 .23986931E-10 .45635598E-10 .14474359E-04
     -.24404005E-10 -.16113/39E-05 .23986931E-10 .45635598E-10 .14474359E-04 -.40550995E-04 -.55846279E-04 -.22604313E-10 .55847713E-04 -.40549100E-04 .22357522E-10 -.51919354E-04 .40814116E-04 -.35835384E-10 .15906312E-09 -.16795738E-09 -.21209458E-04 .16987299E-03 -.27619447E-03 .11979215E-09 -.27619560E-03 .16987149E-03 .57726900E-10 -.17376694E-03 -.27781789E-03 .11764036E-09 .27783864E-03
      -.17373411E-03 .70185849E-10

      .10000000E+01
      -.30291562E-01
      -.76876291E-07
      .73800796E-06
      .32867117E-06

      .13158549E-06
      -.92633251E-08
      -.17952422E-07
      .62673968E-08
      -.19995321E-07

      .20953681E-06
      -.61379992E-07
      .12006683E-09
      -.11753664E-09
      .88805322E-10

        mass matrix
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72836582E-024	46789915E-08	15892413E-07	.65356843E-10	.31383227E-07
	42666551E-09		15001301E-06	.75692354E+00
		30143385E+00		23320214E-01
				42591726E-06
	48891040E-08	.41439984E-06		
	32855064E-08		29885627E-08	
.83112891E-08	55592945E-08	.12118342E+00	12399628E-07	.47190946E-08
31250391E-01 .4	48004340E-01	30017176E-01	.16597444E-08	50976879E-11
.19275352E-09:			45920329E-07	.21718772E-07
	12729912E-07	22012824F=08	16797908E-07	.91574736E-08
			.46204715E-10	
	27168278E+00	.49698521E-01		
.86245755E-08 .8	84823258E-08		27669342E-09	
17209949E-08 .8	803766 4 0E-09	.30587738E-02		55460535E-07
.51525169E-09 .0	56144997E-06	30804574E-06	20159786E-09	.39083720E+00
17696374E+00	30775127E-10	78122412E-12	.14089096E-10	.72836582E-02
	69521649E-10	11823684E-03	73228149E-08	29478674E-07
		22809491E-07		85227134E-07
	11012196E-05	.10593951E-05		.77536846E-05
47261019E-08:	11104159E-07	.25209767E-06		.16366625E-07
.11419001E+00 .2	22910605E-07	.48721700E-07	.94812449E-01	26910936E-01
53138454E-01 .:	10396571E-06	37021885E-07	.17801169E-06	.12499195E-06
	32957092E-07		15204283E-09	.22344016E-10
	11887505E-02	.31354146E-01		44647683E-09
	28098883E-01	.20575968E-08		80118470E-01
19954144E+00	51982556E+00	11311457E-09	.72402280E-09	.51155317E-09
		34933873E+00		
21701737E-06	12705909E-09	.65962710E-07	.12765379E-06	24445245E-09
	92974491E-11	.29258756E-02	.57170319E-09	.11035564E-08
.72527212E-02				.46789915E-08
.15892413E-076		.73228149E-08	.29478674E-07	
.130344535-0/0	11 -15 C#00CCCC		.84364044E-11	.86915796E-11
20205244E-113) 20 2 T 2 C 4 E - T T	.87155679E-04		
.68614717E-023				
	39275247E-05		34017979E-08	.17927404E-06
16399263E-07 .7	/3058140E-08	94493068E-01	48349038E-07	.22872252E-07
.11390138E+00 .5	53141657E-01	26904645E-01	.94708623E-07	.55451004E-07
.26193636E-061	L8332552E-07	35360159E-06	28254188E-07	.38520272E-07
		89135235E-08		.41849538E-02
.191191105-00 .1		.051552552	.515510202 01	

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                                .73095770E-08 .34936258E+00 -.20008846E+00
  .10387562E-07 -.27226537E-08
                .21430064E-06 -.12189418E-06 .18933107E-09 -.13611625E-06
  .35514320E-11
  .63215067E-07 -.27202374E-09 -.76083731E-11 -.16981023E-11 -.72526267E-02
                               .29238966E-02 -.15032889E-07
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  .22809491E-07 -.59107460E-10 -.84364044E-11 -.86915796E-11 -.68614717E-02
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A.4 Concept 3 Definitions and TREETOPS files

Sensor Definitions **Actuator Definitions** Interconnect Definitions

TREETOPS files:

.int, .lin, los.dat, solar_pressure.dat, excerpt of .flx Summer Solstice (SS):

Vernal Equinox (VE): .int Autumnal Equinox (AE): .int Winter Solstice (WS): .int

		Ta	able A.4	.1 Sensor Definiti		s (Concept 3)
Global Sensor Output No.	TREETOPS Sensor Designation	Local Sensor Output No.	Sensor Mount Loc.	Туре	u s c d	DOF
RPI	SE 1	1	B2-N2 B2-N2	Earth Target (ET) (LOS Along X ^{B2})		Pitch (Y ^{B2}) Error - Overall System Yaw (Z ^{B2}) Error - Overall System
RP2 RP3 RP4	SE 1 SE 2 SE 2	2 1 2 3	B2-N2 B2-N2 B2-N2 B2-N2	Star Tracker (ST) (LOS Along Z ^{B2})		Roll (X ⁸²) Error Overall System Not used in control (Pitch (Y ⁸²) Error) Not used in control (Validity Flag on(1) off(0))
RP5 RP6 RP7 RP8	SE 2 SE 3 SE 3 SE 3	1 2 3	B3 N2 B3 N2 B3 N2	LOS Sensor (L) (LOS Along -Y ¹)		Roll (X ^{B3}) Error - Upper Clamshell Pitch (Y ^{B3}) Error - Upper Clamshell Yaw (Z ^{B3}) Error - Upper Clamshell
RP9 RP10 RP11	SE 3 SE 3 SE 3	5 6	B3 -N2 B3 -N2 B3N2	(Negative Polar Axis) see .los file		Not used in control Not used in control Not used in control Not used in control
RP12 RP13 RP14 RP15	SE 3 SE 4 SE 4 SE 4	7 1 2 3	B3-N2 B4-N2 B4-N2 B4-N2	LOS Sensor (L) (LOS Along +Y ¹) (Positive Polar Axis)		Roll (X ^{B4}) Error - Lower Clamshell Pitch (Y ^{B4}) Error - Lower Clamshell Yaw (Z ^{B4}) Error - Lower Clamshell Not used in control
RP16 RP17 RP18 RP19	SE 4 SE 4 SE 4 SE 4	5 6 7	B4-N2 B4-N2 B4-N2 B4-N2	see .los file		Not used in control Not used in control Not used in control Not used in control (Yaw (Z ^{B2}) Error
RP 20 RP 21 RP 22	SE 5 SE 5 SE 5	2 3	B2-N5 B2-N5 B2-N5	Star Tracker (ST) (LOS Along -X ^{B2}) (Towards Sun)		Not used in control (Pitch (Y ^{ss}) Error) Validity Flag on(1) off(0) Used for Rad Pres Distu
RP 23 RP 24	SE 6 SE 6 SE 6	2 3	B2-N2 B2-N2 B2-N2	3 Axis Accelerometer (A3) with gravity removed	_	Not used in control, For Output Only, ACCEL (X ^{B2} Not used in control, For Output Only, ACCEL (Y ^{B2} Not used in control, For Output Only, ACCEL (Z ^{B2})
RP 25	SE 7	1	B2-N2	1 Axis Accelerometer (AC) with gravity removed		Not used in control, For Output Only, ACCEL (X ^{B2}

Table A.4.2 Actuator Definitions (Concept 3)						
Global Actuator Input No.	TREETOPS Actuator Designation	Sensor Mount Loc.	Туре	DOF Overall System		
UP 1 UP 2 UP 3 UP 4 UP 5 UP 6 UP 7 UP 8	AC 1 AC 2 AC 3 AC 4 AC 5 AC 6 AC 7 AC 8	B2-N2 B2-N2 B2-N2 B3-N2 B3-N2 B3-N2 B4-N2 B4-N2	Moment Actuator (MO)*	Pitch (Y ^{B2}) Ext. Torque - Overall System Yaw (Z ^{B2}) Ext. Torque - Overall System Roll (X ^{B2}) Ext. Torque - Overall System Roll (X ^{B3}) Ext. Torque - Upper Clamshell Pitch (Y ^{B3}) Ext. Torque - Upper Clamshell Yaw (Z ^{B3}) Ext. Torque - Upper Clamshell Roll (X ^{B4}) Ext. Torque - Lower Clamshell Pitch (Y ^{B4}) Ext. Torque - Lower Clamshell Yaw (Z ^{B4}) Ext. Torque - Lower Clamshell		
UP 10	AC 10	B2-N5	Reaction Jet (J) Radiation Pressure Disturbance	-X ^{B2} Force at Central Body Transmitter		

Notes:

* Moment Actuator (MO) in TREETOPS is an External Moment applied to a Body (Reacts against Space)

Used in Control

Table A.4.3: Interconnect Data and Significant Parameters for TREETOPS Continuous Matrix (CM) Controller (Concept 3)

Interconnect Data							nuous Ma in xdot y	t Parameters in trix (CM) Controll .lin file = Ax + Bu = Cx + Du	
nter-	Description	S C C A	S No. C No. C No. A No.	S Out No. C In No. C Out No. A In No.	Gain N-m or N	Subset of A Matrix	Subset of B Matrix	Subset of C Matrix ω² 2ζω	Subset of D Matrix
C 1	Pitch (Y ^{B2}) of Overall System	S C	<u>l</u>	1	4.41E13	0. 1.	0	.000025 .007	0
IC 2	, inclination of the state of t	C A	<u>1</u>	<u>1</u>	1.0	-11.4	0		
IC 3	Yaw (Z ^{B2}) of Overall System	S C	<u>1</u>	2	1.67E12	0. 1.	1	.000025 .007	0
IC 4		C A	<u>1</u>	2	4.31E13	0, 1.	0		
IC 5	Roll (X ^{B2}) of Overall System	S C C	<u>2</u>	$\frac{1}{3}$	1.0	-11.4	1	.000025 .007	0
IC 6		Α	3	1	1.7E12	0. 1.	0		
IC 7	Roll (X ^{B3}) of Upper Clamshell	S C C	3 1	4 4	1.72.2	-11.4	1	.0001 .014	0
IC 9		A S	4 3	1 2	1.7E12	0. 1.	0	.0001 .014	0
IC 10	Pitch (Y ^{B3}) of Upper Clamshell	C	<u>1</u> 	5	1.0	-11.4	1		
IC 11	Yaw (Z ^{B3}) of Upper Clamshell	A S C	5 3 1	$\frac{1}{6}$	3.4E12	0. 1.	0	.0001 .014	0
IC 12	Yaw (Z ²²) of Opper Claimshell	C A	1 6	6	1.0	-11.4	1		
IC 13	Roll (X ^{B4}) of Lower Clamshell	<u>S</u> C	4		1.7E12	0. 1.	0	.0001 .014	0
IC 14	Roll (A) of Lower Stationer	C A	1 7	7	1.0	-11.4	1		<u> </u>
IC 15	Pitch (Y ^{B4}) of Lower Clamshell	S	1	8	1.7E12	0. 1.	0	.0001 .014	0
IC 16		C A	1 8 4	1 3	3.4E12	0. 1.	0		-
IC 17	Yaw (Z ^{B4}) of Lower Clamshell	<u>S</u> <u>C</u>	1	9	1.0	-11.4	1	.0001 .014	0
IC 18		A	9	1	7.0				
IC 19	-X ^{B2} of Radiation Pres Disturb	S	5	3	7.0				

isc3_flex_sol.int (Concept 3) Summer Solstice

TREETOPS REV 10P2 4/10/00

SIM CONTROL

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ISC MODEL, THIRD VERSION
        0 Title
 1 SI
                                                                 100000
        0 Simulation stop time
 2 SI
                                                                 20
        0 Plot data interval
 3 SI
                                                                 R
        0 Integration type (R,S,U, OR V)
 4 SI
                                                                  . 1
        0 Step size (sec)
 5 SI
        0 Sandia ODE solver absolute and relative error
 6 SI
        0 RK78 ODE solver absolute error and first step size
 7 SI
        0 Linearization option (L,Z or N)
 8 SI
        0 Restart option (Y/N)
 9 SI
        O Contact force computation option
10 SI
        0 Constraint force computation option (Y/N)
11 SI
        0 Small angle speedup option (All, Bypass, First, Nth)
12 SI
        0 Mass matrix speedup option (All, Bypass, First, Nth) A
14 SI 0 Non-Linear speedup option (All, Bypass, First, Nth) A
15 SI 0 Constraint speedup option (All, Bypass, First, Nth) A
        0 Constraint stabilization option (Y/N)
16 SI
       O Stabilization epsilon
 17 SI
           GENGRAV
        0 Gravity, earth sphere/nonsphere/user (S/N/U)?
         1 Input gravity constants: GME, ERAD, EMASS
         1 Spherical or Nonspherical (S/N)?
        1 Gravity Potential Harmonics J2,J3,J4
 21 GG
 22 GG 0 English (ft-slug-s) or metric (m-kg-s)
                                                                  Μ
                                                        (E/M)?
                                                                  21 6 2020
         O Day, Month, Year,
 23 GG
         0 GMT @ sim time 0 (minutes past midnight,
                                                                  0
 24 GG
                                                                  Υ
         0 Solar Pressure forces Y/N?
         0 Input new data for aero model? (Y/N)
 26 GG
         1 Solar flux F10 for aero model
 27 GG
        1 Solar flux, 81 day average F10B
 28 GG
        1 Geomagnetic index, GEAP
 29 GG
            BODY
         1 Body ID number
 30 BO
                                                                  F
        1 Type (Rigid, Flexible, NASTRAN)
                                                                  24
         1 Number of modes
 32 BO
         1 Modal calculation option (0, 1 or 2)
 33 BO
         1 Foreshortening option (Y/N)
 34 BO
         1 Model reduction method (NO,MS,MC,CC,QM,CV)
 35 BO
         1 NASTRAN data file FORTRAN unit number (40 - 60)
 36 BO
         1 Number of augmented nodes (0 if none)
 37 BO
         1 Damping matrix option (NS,CD,HL,SD)
 38 BO
         1 Constant damping ratio
1 Low frequency, High frequency ratios
 39 BO
 40 BO
         1 Mode ID number, damping ratio
         1 Conversion factors: Length, Mass, Force
  42 BO
          1 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
                                                                   6.2852173E11 6.2852173E11
  43 BO
        1 Moments of inertia (kg-m2) Ixx, Iyy, Izz
  44 BO
6.7057352E8
         1 Products of inertia (kg-m2) Ixy,Ixz,Iyz
1 Mass (kg)
                                                                   0 0 0
  45 BO
                                                                  1.6168633E5
  46 BO
                                                                   4
         1 Number of Nodes
                                                                   1 0 0 0
         1 Node ID, Node coord. (meters) x,y,z
1 Node ID, Node coord. (meters) x,y,z
  48 BO
                                                                  2 0 0 0
  49 BO
                                                                  3 0 0 3188.8
         1 Node ID, Node coord. (meters) x,y,z
1 Node ID, Node coord. (meters) x,y,z
  50 BO
                                                                   4 0 0 -3188.8
  51 BO
         1 Node ID, Node structual joint ID
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         2 Body ID number
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Contract No. Bd Systems® NAS8-00151 TCD20000222A Final Report 29 December 2000 R 54 BO 2 Type (Rigid, Flexible, NASTRAN) 2 Number of modes 2 Modal calculation option (0, 1 or 2) 56 BO 57 BO $\,$ 2 Foreshortening option (Y/N) 58 BO 2 Model reduction method (NO,MS,MC,CC,QM,CV)
59 BO 2 NASTRAN data file FORTRAN unit number (40 - 60)
60 BO 2 Number of augmented nodes (0 if none) 61 BO 2 Damping matrix option (NS,CD,HL,SD) 62 BO 2 Constant damping ratio 2 Low frequency, High frequency ratios 63 BO 64 BO 2 Mode ID number, damping ratio 65 BO 2 Conversion factors: Length, Mass, Force 2 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 66 BO .8543E12 1.5601E12 2 Moments of inertia (kg-m2) Ixx, Iyy, Izz 67 BO 1.3822E12 68 BO 2 Products of inertia (kg-m2) Ixy,Ixz,Iyz 0 0 0 12666300 2 Mass (kg) 69 BO 2 Number of Nodes 1 298.323 0 0 70 BO 2 Node ID, Node coord. (meters) x,y,z 2 0 0 0 3 0 3 0 0 71 BO 2 Node ID, Node coord. (meters) x,y,z 72 BO 2 Node ID, Node coord. (meters) x,y,z 73 BO 4 0 0 -300 2 Node ID, Node coord. (meters) x,y,z 74 BO 2 Node ID, Node coord. (meters) x,y,z 5 500 0 0 75 BO 76 BO 2 Node ID, Node structual joint ID 3 77 BO 3 Body ID number 78 BO 3 Type (Rigid, Flexible, NASTRAN) R 3 Number of modes 79 BO 80 BO 3 Modal calculation option (0, 1 or 2) 81 BO 3 Foreshortening option (Y/N) 82 BO 3 Model reduction method (NO,MS,MC,CC,QM,CV) 83 BO 3 NASTRAN data file FORTRAN unit number (40 3 NASTRAN data file FORTRAN unit number (40 - 60) 84 BO 3 Number of augmented nodes (0 if none) 85 BO 3 Damping matrix option (NS,CD,HL,SD) 86 BO 3 Constant damping ratio 87 BO 3 Low frequency, High frequency ratios 88 BO 3 Mode ID number, damping ratio 89 BO 3 Conversion factors: Length, Mass, Force 3 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 91 BO 3 Moments of inertia (kg-m2) Ixx, Iyy, Izz 1.7E12 1.7E12 3.4E12 0 0 0 92 BO 3 Products of inertia (kg-m2) Ixy,Ixz,Iyz 2046600 3 Mass (kg) 3 Number of Nodes 93 BO 94 BO 1 0 0 0 3 Node ID, Node coord. (meters) x,y,z 95 BO 2 0 0 0 3 Node ID, Node coord. (meters) x,y,z 96 BO 3 Node ID, Node structual joint ID 97 BO 4 4 Body ID number 98 BO 4 Type (Rigid, Flexible, NASTRAN) 4 Number of modes 99 BO 100 BO 101 BO 4 Modal calculation option (0, 1 or 2) 4 Foreshortening option (Y/N) 102 BO 4 Model reduction method (NO,MS,MC,CC,QM,CV) 103 BO 4 NASTRAN data file FORTRAN unit number (40 - 60) 104 BO 4 Number of augmented nodes (0 if none) 105 BO 4 Damping matrix option (NS,CD,HL,SD) 4 Constant damping ratio 106 BO 107 BO 4 Low frequency, High frequency ratios 108 BO 4 Mode ID number, damping ratio 109 BO 4 Conversion factors: Length, Mass, Force 110 BO 4 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 4 Moments of inertia (kg-m2) Ixx, Iyy, Izz 1.7E12 1.7E12 3.4E12 Products of inertia (kg-m2) Ixy, Ixz, Iyz 0 0 0 4 Mass (kg) 2046600 111 BO 112 BO 113 BO 114 BO 115 BO 4 Number of Nodes 116 BO 4 Node ID, Node coord. (meters) x,y,z 1 0 0 0 2 0 0 0 4 Node ID, Node coord. (meters) x,y,z 117 BO 118 BO 4 Node ID, Node structual joint ID

HINGE

29 Decemb	CI 2000	
119 HI 120 HI	1 Hinge ID number 1 Inboard body ID, Outboard body ID	1 0 1 0 2
121 HI	a " "	3 F
122 HI	1 "p" node 1D, q node 13 1 Number of rotation DOFs, Rotation option (F or G) 1 L1 unit vector in inboard body coord. x,y,z	1 0 0
123 HI	1 11 unit wester in outboard body could. A/1/2	1 0 0
124 HI 125 HI	1 12 unit wester in inboard body coold. A, y, 2	
125 HI 126 HI	1 to whit wector in outboard body coold. A, y, 2	0 0 1
127 HI	1 12 unit vector in inboard body Coord, X,Y,2	0 0 1 0 0 1
128 HI	1 13 unit vector in outboard body coord. X,y,2	-90 0 90
129 HI	1 Initial rotation angles (deg)	0 0 0.00417807
130 HI	1 Initial rotation rates (deg/sec) 1 Rotation stiffness (newton-meters/rad)	0 0 0
131 HI 132 HI	1 Rotation damping (newton-meters/rad/sec)	0 0 0
132 HI	1 Null torque angles (deg)	0 0 0
134 HI	1 Number of translation DOFs	3 1 0 0
135 HI	1 First translation unit vector g1	0 1 0
136 HI	1 Second translation unit vector g2 1 Third translation unit vector g3	0 0 1
137 HI	1 Initial translation (meters)	0 0 42163421
138 HI 139 HI	1 Initial translation velocity (meters/sec)	3074.681 0 0
139 HI 140 HI	1 Translation stiffness (newtons/meters)	0 0 0
141 HI	1 Translation damping (newtons/meter/sec)	0 0 0
142 HI	1 Null force translations	0 0 0
	and the second s	2
143 HI	2 Hinge ID number 2 Inboard body ID, Outboard body ID	1 2
144 HI	2 "p" node ID, "q" node ID	2 2
145 HI 146 HI	2 Number of rotation DOFS	0
147 HI	a 11 unit wester in inheard body coord, X,Y,Z	0 0 1 0 0 1
148 HI	2 L1 unit vector in outboard body coord. x,y,z	0 0 1
149 HI	2 L2 unit vector in inboard body coord. x,y,z 2 L2 unit vector in outboard body coord. x,y,z	
150 HI	a ra unit weeter in inboard body coold, X,y,2	1 0 0
151 HI 152 HI	2 13 unit vector in outboard body coold. X,y,2	1 0 0
152 HI	2 Initial rotation angles (deg)	0 0 0
154 HI	2 Initial rotation rates (deg/sec)	
155 HI	2 Rotation stiffness (newton-meters/rad) 2 Rotation damping (newton-meters/rad/sec)	
156 HI	2 Null torque angles (deg)	
157 HI 158 HI	2 Number of translation DOFs	0
150 HI	2 First translation unit vector gl	1 0 0 0 1 0
160 HI	2 Second translation unit vector g2	0 0 1
161 HI	2 Third translation unit vector g3	0 0 0
162 HI	2 Initial translation (meters) 2 Initial translation velocity (meters/sec)	
163 HI	2 Translation stiffness (newtons/meters)	
164 HI 165 HI	2 Translation damping (newtons/meter/sec)	
166 HI	2 Null force translations	
	TR well as	3
167 HI	3 Hinge ID number 3 Inboard body ID, Outboard body ID	1 3
168 HI 169 HI	3 "p" node ID, "q" node ID	3 2
170 HI	a Number of rotation DOFS	3 0 0 1
171 HI	a ti writ wagter in inboard body coord. X,Y,Z	0 0 1
172 HI	3 L1 unit vector in outboard body coord. x,y,z	0 0 1
173 HI	3 L2 unit vector in inboard body coord. x,y,z 3 L2 unit vector in outboard body coord. x,y,z	
174 HI	a ra unit moster in inheard body coord, X,Y,Z	0 1 0
175 HI 176 HI	3 1.3 unit vector in outboard body coord. X,y,2	0 1 0
177 HI	a Initial rotation angles (deg)	90 0 -123.25 -0.004178 0 0
178 HI	<pre>2 Initial rotation rates (deg/sec)</pre>	0 0 0
179 HI	3 Rotation stiffness (newton-meters/rad) 3 Rotation damping (newton-meters/rad/sec)	0 0 0
180 HI	3 Null torque angles (deg)	0 0 0
181 HI 182 HI	3 Number of translation DOFS	0
183 HI	3 First translation unit vector g1	1 0 0 0 1 0
184 HI	3 Second translation unit vector g2	0 0 1
185 HI	3 Third translation unit vector g3	0 0 0
186 HI	3 Initial translation (meters)	

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           3 Initial translation velocity (meters/sec)
             3 Translation stiffness (newtons/meters)
             3 Translation damping (newtons/meter/sec)
 189 HI
 190 HI 3 Null force translations
 191 HI 4 Hinge ID number
192 HI 4 Inboard body ID, Outboard body ID
                                                                                       4 2
 193 HI 4 "p" node ID, "q" node ID
 194 HI 4 Number of rotation DOFs
                                                                                      0 0 1
             4 L1 unit vector in inboard body coord. x,y,z
 195 HI
 196 HI 4 L1 unit vector in outboard body coord. x,y,z
                                                                                      0 0 1
 197 HI 4 L2 unit vector in inboard body coord. x,y,z
 198 HI 4 L2 unit vector in outboard body coord. x,y,z
199 HI 4 L3 unit vector in inboard body coord. x,y,z
                                                                                   0 1 0
 200 HI 4 L3 unit vector in outboard body coord. x,y,z
                                                                                    90 0 -33.25
-0.004178 0 0
 201 HI 4 Initial rotation angles (deg)
 202 HI 4 Initial rotation rates (deg/sec)
203 HI 4 Rotation stiffness (newton-meters/rad)
                                                                                     0 0 0
 204 HI 4 Rotation damping (newton-meters/rad/sec)
 204 HI 4 Rotation damping (newton-meters/rad/set 205 HI 4 Null torque angles (deg) 206 HI 4 Number of translation DOFs 207 HI 4 First translation unit vector g1 208 HI 4 Second translation unit vector g2 209 HI 4 Third translation unit vector g3 210 HI 4 Initial translation (meters) 211 HI 4 Initial translation velocity (meters/set)
                                                                                       0 0 0
                                                                                     1 0 0
                                                                                      0 1 0
                                                                                       0 0 1
                                                                                      0 0 0
  211 HI 4 Initial translation velocity (meters/sec)
  212 HI 4 Translation stiffness (newtons/meters)
213 HI 4 Translation damping (newtons/meter/sec)
214 HI 4 Null force translations
                 SENSOR
  215 SE 1 Sensor ID number
  216 SE 1 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ET 217 SE 1 Mounting point body ID, Mounting point node ID 2:
  218 SE 1 Second mounting point body ID, Second node ID
  219 SE 1 Input axis unit vector (IA) x,y,z
              1 Mounting point Hinge index, Axis index
  220 SE 1 Mounting point Hinge index, Axis index
221 SE 1 First focal plane unit vector (Fp1) x,y,z 0 0 -1
222 SE 1 Second focal plane unit vector (Fp2) x,y,z 0 1 0
   223 SE 1 Sun/Star unit vector (Us) x,y,z
224 SE 1 Velocity Aberration Option (Y/N)
   225 SE 1 Euler Angle Sequence (1-6)
   226 SE 1 CMG ID number and Gimbal number
              1 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 6378000 0 0 4.178074D-3
   227 SE
   228 SE 2 Sensor ID number
   229 SE 2 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST
230 SE 2 Mounting point body ID Mounting point node ID 2
               2 Mounting point body ID, Mounting point node ID
   230 SE
   231 SE 2 Second mounting point body ID, Second node ID
   232 SE 2 Input axis unit vector (IA) x,y,z
               2 Mounting point Hinge index, Axis index
   233 SE
              2 First focal plane unit vector (Fp1) x,y,z
2 Second focal plane unit vector (Fp2) x,y,z
                                                                                        0 -1 0
   234 SE
                                                                                        1 0 0
   235 SE
                                                                                         0 1 0
              2 Sun/Star unit vector (Us) x,y,z
2 Velocity Aberration Option (Y/N)
   236 SE
                                                                                        N
   237 SE
              2 Euler Angle Sequence (1-6)
   238 SE
   239 SE 2 CMG ID number and Gimbal number
240 SE 2 Earth pt (rad,lat,lon,rotation [m/e, d, d, d/s])
   241 SE 3 Sensor ID number
   242 SE 3 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) L
243 SE 3 Mounting point body ID, Mounting point node ID 3
   244 SE 3 Second mounting point body ID, Second node ID
   245 SE 3 Input axis unit vector (IA) x,y,z
                                                                                         1 2 3
                3 Mounting point Hinge index, Axis index
    246 SE
   247 SE 3 First focal plane unit vector (Fp1) x,y,z
248 SE 3 Second focal plane unit vector (Fp2) x,y,z
              3 Sun/Star unit vector (Us) x,y,z
3 Velocity Aberration Option (Y/N)
    249 SE
    250 SE
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Bd Systems® TCD20000222A 29 December 2000 3 Euler Angle Sequence (1-6) 3 CMG ID number and Gimbal number 3 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 253 SE 4 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) 4 Sensor ID number 254 SE 4 Mounting point body ID, Mounting point node ID 255 SE 256 SE 4 Second mounting point body ID, Second node ID 257 SE 3 2 1 4 Input axis unit vector (IA) x,y,z 4 Mounting point Hinge index, Axis index 259 SE 4 First focal plane unit vector (Fp1) x,y,z 260 SE 4 Second focal plane unit vector (Fp2) x,y,z 261 SE 4 Sun/Star unit vector (Us) x,y,z 262 SE 4 Velocity Aberration Option (Y/N) 4 Euler Angle Sequence (1-6) 263 SE 264 SE 4 CMG ID number and Gimbal number 265 SE 266 SE 4 Earth pt (rad,lat,lon,rotation [m/e, d, d, d/s]) 5 Sensor ID number 5 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST 267 SE 268 SE 5 Mounting point body ID, Mounting point node ID 5 Second mounting point body ID, Second node ID 269 SE 270 SE 5 Input axis unit vector (IA) x,y,z271 SE 5 Mounting point Hinge index, Axis index 272 SE 0 0 1 5 First focal plane unit vector (Fp1) x,y,z273 SE 0 -1 0 5 Second focal plane unit vector (Fp2) x,y,z 274 SE 0 0 0 5 Sun/Star unit vector (Us) x,y,z 275 SE 5 Velocity Aberration Option (Y/N) 276 SE 5 Euler Angle Sequence (1-6) 277 SE 5 CMG ID number and Gimbal number 278 SE 5 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 279 SE 6 Sensor ID number 6 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV A3 280 SE 282 SE 6 Mounting point body ID, Mounting point node ID 281 SE 6 Second mounting point body ID, Second node ID 283 SE 6 Input axis unit vector (IA) x,y,z 284 SE 285 SE 6 Mounting point Hinge index, Axis index 286 SE 6 First focal plane unit vector (Fp1) x,y,z 6 Second focal plane unit vector (Fp2) x,y,z 287 SE 288 SE 6 Sun/Star unit vector (Us) x,y,z 289 SE 6 Velocity Aberration Option (Y/N) 290 SE 6 Euler Angle Sequence (1-6) 6 CMG ID number and Gimbal number 291 SE 6 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 292 SE 7 Sensor ID number 7 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV AC 293 SE 294 SE 7 Mounting point body ID, Mounting point node ID 295 SE 7 Second mounting point body ID, Second node ID 7 Input axis unit vector (IA) x,y,z 296 SE 1 0 0 297 SE 7 Mounting point Hinge index, Axis index 298 SE 7 First focal plane unit vector (Fp1) x,y,z 299 SE 7 Second focal plane unit vector (Fp2) x,y,z300 SE 7 Sun/Star unit vector (Us) x,y,z 301 SE 7 Velocity Aberration Option (Y/N) 302 SE 7 Euler Angle Sequence (1-6) 303 SE 7 CMG ID number and Gimbal number 304 SE 7 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 305 SE ACTR 1 Actuator ID number 306 AC 1 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 308 AC 1 Actuator location; Node or Hinge (N or H) 307 AC 309 AC 1 Mounting point body ID number, node ID number 2 2 1 Second mounting point body ID, second node ID 310 AC 0 1 0 1 Output axis unit vector x,y,z311 AC 1 Mounting point Hinge index, Axis index 312 AC 1 Rotor spin axis unit vector x,y,z 313 AC

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Bd Systems® TCD20000222A 29 December 2000 1 Initial rotor momentum, H 314 AC 1 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 315 AC 1 Outer gimbal axis unit vector x,y,z 316 AC 1 Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 317 AC 1 Inner gimbal- angle(deg), inertia, friction(D,S,B,N) 318 AC 1 Inner gimbal axis unit vector x,y,z 319 AC 1 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 320 AC 1 Initial length and rate, y(to) and ydot(to) 321 AC 1 Constants; K1 or wo, n or zeta, Kg, Jm 322 AC 1 Non-linearities; TLim, Tco, Dz 323 AC 2 Actuator ID number 324 AC 2 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) MO 325 AC 2 Actuator location; Node or Hinge (N or H) 326 AC 2 Mounting point body ID number, node ID number 2 2 327 AC 2 Second mounting point body ID, second node ID 328 AC 0 0 1 2 Output axis unit vector x,y,z 329 AC 2 Mounting point Hinge index, Axis index 330 AC 2 Rotor spin axis unit vector x,y,z 331 AC 2 Initial rotor momentum, H 332 AC 2 Outer gimbal- angle(deg), inertia, friction(D,S,B,N) 333 AC 2 Outer gimbal axis unit vector x,y,z334 AC 2 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)
2 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 335 AC 336 AC 2 Inner gimbal axis unit vector x,y,z 337 AC 2 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 338 AC 2 Initial length and rate, y(to) and ydot(to) 339 AC 2 Constants; K1 or wo, n or zeta, Kg, Jm 340 AC 2 Non-linearities; TLim, Tco, Dz 341 AC 3 Actuator ID number 342 AC MO 3 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 343 AC 3 Actuator location; Node or Hinge (N or H) 344 AC 3 Mounting point body ID number, node ID number 2 2 345 AC 3 Second mounting point body ID, second node ID 346 AC 1 0 0 3 Output axis unit vector x,y,z 347 AC 3 Mounting point Hinge index, Axis index 348 AC 3 Rotor spin axis unit vector x,y,z349 AC 3 Initial rotor momentum, H 350 AC 3 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 351 AC 3 Outer gimbal axis unit vector x,y,z352 AC 3 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 353 AC 3 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 354 AC 3 Inner gimbal axis unit vector x,y,z355 AC 3 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 356 AC 3 Initial length and rate, y(to) and ydot(to) 357 AC 3 Constants; K1 or wo, n or zeta, Kg, Jm 358 AC 3 Non-linearities; TLim, Tco, Dz 359 AC 4 Actuator ID number 360 AC MO 4 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 361 AC 4 Actuator location; Node or Hinge (N or H) 362 AC 4 Mounting point body ID number, node ID number 363 AC 4 Second mounting point body ID, second node ID 364 AC 1 0 0 4 Output axis unit vector x,y,z 365 AC 4 Mounting point Hinge index, Axis index 366 AC 4 Rotor spin axis unit vector x,y,z 367 AC 4 Initial rotor momentum, H 368 AC 4 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 369 AC 4 Outer gimbal axis unit vector x, y, z370 AC 4 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 371 AC 4 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 372 AC 4 Inner gimbal axis unit vector x,y,z 373 AC 4 In gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 374 AC 4 Initial length and rate, y(to) and ydot(to) 375 AC 4 Constants; K1 or wo, n or zeta, Kg, Jm 376 AC 4 Non-linearities; TLim, Tco, Dz 377 AC 5 Actuator ID number 378 AC 5 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) MO 379 AC 5 Actuator location; Node or Hinge (N or H) 380 AC

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	the second body II) number, node in named	3 2
	Second mounting point body ID, second node ID	0 1 0
202 20 5	output axis unit vector X,Y,2	0 1 0
204 70 5	Mounting point Hinge index, Axis index	
205 10 5	Rotor spin axis unit vector x,y,2	
	Initial rotor momentum, H Outer gimbal- angle(deg), inertia, friction(D,S,B,N)	
_		
200 10 0	Innor gimbal- angle(deg), inertia, iliccion(b, b, b, b, m,	
_	bal awid unit Vector X, Y, 4	
	fyia /mfi mato.(jAM)/(TLI,M,D,RI)/(M)/-/-/-/-/	
[r This length and rate, V(to) and ydocker,	
204 10 5	5 Constants; K1 or wo, n or zeta, Kg, Jm	
395 AC	5 Non-linearities; TLim, Tco, Dz	
	6 Actuator ID number	6
	c manager if MO TO B MA.SG.DG.W.D.MITM/)	MO
	· · · · · · · · · logation NOOP Of Billy \ \text{V}	3 2
	a to bloom body (i) himper, node in hame -	3 2
400 30	6 Second mounting point body ib, Second in	0 0 1
	6 Output axis unit vector x,y,z	
	6 Output days unit Hinge index, Axis index 6 Rotor spin axis unit vector x,y,z	
404 AC	c Outor gimbal - angle (deg), inertia, iliction (5,5,5,1),	
405 AC 406 AC		
400 AC		
408 AC	6 Inner gimbal - angle (deg), Inercia, Illection (1, 1, 1)	
409 AC	6 Inner gimbal axis unit vector x,y,z 6 Inner gimbal axis unit vector x,y,z 6 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 6 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)	
410 AC	6 In gim fric (TII,1gIO,GARI)	
411 AC	6 Constants; K1 or wo, n or zeta, Kg, Jm	
412 AC 413 AC	6 Non-linearities; TLim, Tco, Dz	
415 AC		7
414 AC	7 Actuator ID number	MO
414 AC 415 AC	π π \rightarrow π	МО
415 AC 416 AC	7 Type(J,H,MO,T,B,MA,SG,DG,W,L,MI-M7) 7 Actuator location; Node or Hinge (N or H) 7 Actuator point body ID number, node ID number	MO 4 2
415 AC 416 AC 417 AC	7 Type(J,H,MO,T,B,MA,SG,DG,W,L,MI-M7) 7 Actuator location; Node or Hinge (N or H) 7 Actuator point body ID number, node ID number	4 2
415 AC 416 AC 417 AC 418 AC	7 Type(J,H,MO,T,B,MA,SG,DG,W,L,MI-M/) 7 Actuator location; Node or Hinge (N or H) 7 Mounting point body ID number, node ID number 7 Second mounting point body ID, second node ID	
415 AC 416 AC 417 AC 418 AC 419 AC	7 Type(J,H,MO,T,B,MA,SG,DG,W,L,MI-M/) 7 Actuator location; Node or Hinge (N or H) 7 Mounting point body ID number, node ID number 7 Second mounting point body ID, second node ID 7 Output axis unit vector x,y,z 7 Mounting point Hinge index, Axis index	4 2
415 AC 416 AC 417 AC 418 AC 419 AC 420 AC	7 Type(J,H,MO,T,B,MA,SG,DG,W,L,MI-M/) 7 Actuator location; Node or Hinge (N or H) 7 Mounting point body ID number, node ID number 7 Second mounting point body ID, second node ID 7 Output axis unit vector x,y,z 7 Mounting point Hinge index, Axis index 7 Rotor spin axis unit vector x,y,z	4 2
415 AC 416 AC 417 AC 418 AC 419 AC	7 Type(J,H,MO,T,B,MA,SG,DG,W,L,MI-M7) 7 Actuator location; Node or Hinge (N or H) 7 Mounting point body ID number, node ID number 7 Second mounting point body ID, second node ID 7 Output axis unit vector x,y,z 7 Mounting point Hinge index, Axis index 7 Rotor spin axis unit vector x,y,z	4 2 1 0 0
415 AC 416 AC 417 AC 418 AC 419 AC 420 AC 421 AC	7 Type(J,H,MO,T,B,MA,SG,DG,W,L,MI-M7) 7 Actuator location; Node or Hinge (N or H) 7 Mounting point body ID number, node ID number 7 Second mounting point body ID, second node ID 7 Output axis unit vector x,y,z 7 Mounting point Hinge index, Axis index 7 Rotor spin axis unit vector x,y,z 7 Initial rotor momentum, H 7 Outer gimbal angle(deg), inertia, friction(D,S,B,N)	4 2 1 0 0
415 AC 416 AC 417 AC 418 AC 419 AC 420 AC 421 AC 422 AC 423 AC 424 AC	7 Type(J,H,MO,T,B,MA,SG,DG,W,L,MI-MT) 7 Actuator location; Node or Hinge (N or H) 7 Mounting point body ID number, node ID number 7 Second mounting point body ID, second node ID 7 Output axis unit vector x,y,z 7 Mounting point Hinge index, Axis index 7 Rotor spin axis unit vector x,y,z 7 Initial rotor momentum, H 7 Outer gimbal - angle(deg), inertia, friction(D,S,B,N) 7 Outer gimbal axis unit vector x,y,z	4 2 1 0 0
415 AC 416 AC 417 AC 418 AC 419 AC 420 AC 421 AC 422 AC 423 AC 424 AC 425 AC	7 Type(J,H,MO,T,B,MA,SG,DG,W,L,MI-M/) 7 Actuator location; Node or Hinge (N or H) 7 Mounting point body ID number, node ID number 7 Second mounting point body ID, second node ID 7 Output axis unit vector x,y,z 7 Mounting point Hinge index, Axis index 7 Rotor spin axis unit vector x,y,z 7 Initial rotor momentum, H 7 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 7 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 7 Inper gimbal- angle(deg),inertia,friction(D,S,B,N)	4 2 1 0 0
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415 AC 416 AC 417 AC 418 AC 419 AC 420 AC 421 AC 422 AC 423 AC 424 AC 425 AC 426 AC 427 AC 428 AC 429 AC 431 AC 431 AC 431 AC 432 AC 433 AC 434 AC 435 AC 436 AC 437 AC 438 AC 439 AC 441 AC 442 AC 443 AC 444 AC 445 AC 445 AC 446 AC	7 Type(J,H,MO,T,B,MA,SG,DG,W,L,MI-M/) 7 Actuator location; Node or Hinge (N or H) 7 Mounting point body ID number, node ID number 7 Second mounting point body ID, second node ID 7 Output axis unit vector x,y,z 7 Mounting point Hinge index, Axis index 7 Rotor spin axis unit vector x,y,z 7 Initial rotor momentum, H 7 Outer gimbal axis unit vector x,y,z 7 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 7 Inner gimbal axis unit vector x,y,z 7 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 7 Inner gimbal axis unit vector x,y,z 7 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 7 Initial length and rate, y(to) and ydot(to) 7 Constants; K1 or wo, n or zeta, Kg, Jm 7 Non-linearities; TLim, Tco, Dz 8 Actuator ID number 8 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 8 Actuator location; Node or Hinge (N or H) 8 Mounting point body ID number, node ID number 8 Second mounting point body ID, second node ID 8 Output axis unit vector x,y,z 8 Mounting point Hinge index, Axis index 8 Rotor spin axis unit vector x,y,z 8 Initial rotor momentum, H 8 Outer gimbal angle(deg), inertia, friction(D,S,B,C) 8 Outer gimbal axis unit vector x,y,z 8 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,C) 8 Inner gimbal axis unit vector x,y,z 8 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,C) 8 Inner gimbal axis unit vector x,y,z 8 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,C) 8 Inner gimbal length and rate, y(to) and ydot(to)	4 2 1 0 0 (i) (i) (i) (ii) 8 MO 4 2 0 1 0
415 AC 416 AC 417 AC 418 AC 419 AC 420 AC 421 AC 422 AC 423 AC 424 AC 425 AC 426 AC 427 AC 428 AC 429 AC 430 AC 431 AC 431 AC 431 AC 432 AC 433 AC 434 AC 435 AC 436 AC 437 AC 438 AC 439 AC 441 AC 441 AC 442 AC 444 AC 444 AC	7 Type(J,H,MO,T,B,MA,SG,DG,W,L,MI-MY) 7 Actuator location; Node or Hinge (N or H) 7 Mounting point body ID number, node ID number 7 Second mounting point body ID, second node ID 7 Output axis unit vector x,y,z 7 Mounting point Hinge index, Axis index 7 Rotor spin axis unit vector x,y,z 7 Initial rotor momentum, H 7 Outer gimbal- angle(deg), inertia, friction(D,S,B,N) 7 Outer gimbal axis unit vector x,y,z 7 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 7 Inner gimbal axis unit vector x,y,z 7 Ingim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 7 Inner gimbal axis unit vector x,y,z 8 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 9 Total length and rate, y(to) and ydot(to) 9 Constants; K1 or wo, n or zeta, Kg, Jm 9 Non-linearities; TLim, Tco, Dz 9 Actuator ID number 9 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 9 Actuator location; Node or Hinge (N or H) 9 Mounting point body ID number, node ID number 9 Second mounting point body ID, second node ID 9 Output axis unit vector x,y,z 9 Mounting point Hinge index, Axis index 9 Rotor spin axis unit vector x,y,z 9 Initial rotor momentum, H 9 Outer gimbal angle(deg), inertia, friction(D,S,B,C) 9 Outer gimbal axis unit vector x,y,z 9 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,C) 9 Inner gimbal angle(deg), inertia, friction(D,S,B,C) 9 Inner gimbal angle(deg), inertia, friction(D,S,B,C) 9 Inner gimbal angle (deg), inertia, fr	4 2 1 0 0 (i) (i) (i) (ii) 8 MO 4 2 0 1 0

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Bd Systems® TCD20000222A 29 December 2000 449 AC 8 Non-linearities; TLim, Tco, Dz

		^
450 AC	9 Actuator ID number	9 MO
451 AC	9 Type (J, H, MO, T, B, MA, SG, DG, W, L, M1-M7, US)	110
452 AC	9 Actuator location; Node or Hinge (N or H) 9 Mounting point body ID number, node ID number	4 2
453 AC	9 Second mounting point body ID, second node ID	
454 AC	9 Output axis unit vector x,y,z	0 0 1
455 AC	9 Mounting point Hinge index, Axis index	
456 AC	9 Rotor spin axis unit vector x,y,z	
457 AC 458 AC	a r 'rial motor momentum H	
450 AC	9 Outer gimbal- angle(deg), inertia, friction(D, 3, B, N)	
460 AC	a a tem wimbal axis unit vector X,V,2	
461 AC	~ 2.0 min frig (Tfi Tafo.GAM)/(Tfi,M,D,Ki)/(M,M,D,K)	
462 AC	a Inner gimbal- angle(deg), inertia, friction(b, b, b, m,	
463 AC	9 Inner gimbal axis unit vector x,y,z	
464 AC	9 Inner glimbar dx15 data that the state of	
465 AC	9 Constants; K1 or wo, n or zeta, Kg, Jm	
466 AC	9 Non-linearities; TLim, Tco, Dz	
467 AC	y Non-linearities, 122m,	
468 AC	10 Actuator ID number	10
469 AC	10 Physical H MO T B. MA. SG, DG, W, L, MI-M/, US)	J
470 AC	10 Actuator location: Node or Hinge (N Oi H)	2 5
471 AC	10 Mounting point body ID number, node ID Humber	2 3
472 AC	10 Second mounting point body ID, second node ID	-1 0 0
473 AC	10 Output axis unit vector x,y,z	
474 AC	10 Mounting point Hinge index, Axis index 10 Rotor spin axis unit vector x,y,z	
475 AC	10 - 111-1 motor momentum H	
476 AC	10 Initial rotor momentum, 11 10 Outer gimbal- angle(deg), inertia, friction(D, S, B, N)	
477 AC 478 AC	10 Out on wimbal axis unit Vector X, V, 4	
478 AC	-10 out win frig (Pfi Pafo GAM)/(Tf1,M,D,K1)/(M,M,D,K)	
480 AC	10 Inner gimbal- angle(deg), inertia, filetion(b, b, b, h,	
481 AC	10 Towar gimbal axis unit Vector X, Y, Z	
482 AC	10 Inner gimbar data data and the second of	
483 AC	10 Initial length and rate, y(to) and ydot(to) 10 Constants; K1 or wo, n or zeta, Kg, Jm	
484 AC	10 Constants; KI of Wo, H of Zeta, kg, Tall 10 Non-linearities; Thim, Tco, Dz	
485 AC	10 Non-linearities, Illim, 100, 1-	
	CONTROLLER	
		1
486 CO	1 Controller ID number	CM
487 CO	1 Controller type (CB,CM,DB,DM,UC,UD)	
488 CO	1 Sample time (sec) 1 Number of inputs, Number of outputs	9 9
489 CO 490 CO	1 Number of states	
490 CO 491 CO	1 Output No., Input type (I,S,T), Input ID, Gain	
471 00		
	INTERCONNECT	
492 IN	1 Interconnect ID number	1
492 IN 493 IN	1 Course type(S.C. or F), Source ID, Source IOW #	S 1 1
494 IN		C 1 1
495 IN		4.41E13
		2
496 IN	<pre>2 Interconnect ID number 2 Source type(S,C, or F),Source ID,Source row #</pre>	C 1 1
497 IN	The second of th	A 1 1
498 IN		1
499 IN	Z Gain	_
500 IN	3 Interconnect ID number	3
501 IN	3 Course type(S C or F). Source ID, Source IOW #	S 1 2 C 1 2
502 IN		1.67E12
503 IN		1.3.22
	In number	4
504 IN		C 1 2
505 IN	· · · · · · · · · · · · · · · · · · ·	A 2 1
506 IN	7 Depotitions of the control of the	

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29 December 2000	0	1
507 IN 4 Gai		1
	erconnect ID number rce type(S,C, or F),Source ID,Source row # tination type(A or C),Dest ID,Dest row # n	5 S 2 1 C 1 3 4.31E13
	erconnect ID number arce type(S,C, or F),Source ID,Source row # stination type(A or C),Dest ID,Dest row # .n	6 C 1 3 A 3 1
- 5 6	erconnect ID number arce type(S,C, or F),Source ID,Source row # stination type(A or C),Dest ID,Dest row # in	7 S 3 1 C 1 4 1.7E12
0 0+-	terconnect ID number arce type(S,C, or F),Source ID,Source row # stination type(A or C),Dest ID,Dest row # in	8 C 1 4 A 4 1 1
	terconnect ID number urce type(S,C, or F),Source ID,Source row # stination type(A or C),Dest ID,Dest row # in	9 S 3 2 C 1 5 1.7E12
	terconnect ID number urce type(S,C, or F),Source ID,Source row # estination type(A or C),Dest ID,Dest row # in	10 C 1 5 A 5 1 1
	uterconnect ID number ource type(S,C, or F),Source ID,Source row # estination type(A or C),Dest ID,Dest row #	11 S 3 3 C 1 6 3.4E12
	nterconnect ID number ource type(S,C, or F),Source ID,Source row # estination type(A or C),Dest ID,Dest row # ain	12 C 1 6 A 6 1
540 IN 13 I	nterconnect ID number purce type(S,C, or F),Source ID,Source row # estination type(A or C),Dest ID,Dest row # ain	13 S 4 1 C 1 7 1.7E12
544 IN 14 I	nterconnect ID number ource type(S,C, or F),Source ID,Source row # estination type(A or C),Dest ID,Dest row # ain	14 C 1 7 A 7 1 1
548 IN 15 I	nterconnect ID number ource type(S,C, or F),Source ID,Source row # estination type(A or C),Dest ID,Dest row #	15 S 4 2 C 1 8 1.7E12
552 IN 16 I	nterconnect ID number Source type(S,C, or F),Source ID,Source row # Destination type(A or C),Dest ID,Dest row #	16 C 1 8 A 8 1 1
556 IN 17 I	Interconnect ID number Source type(S,C, or F),Source ID,Source row # Destination type(A or C),Dest ID,Dest row # Gain	17 S 4 3 C 1 9 3.4E12
560 IN 18 5 561 IN 18 5 562 IN 18 I	Interconnect ID number Source type(S,C, or F),Source ID,Source row # Destination type(A or C),Dest ID,Dest row # Gain	18 C 1 9 A 9 1 1

```
564 IN 19 Interconnect ID number
565 IN 19 Source type(S,C, or F),Source ID,Source row # S 5 3
566 IN 19 Destination type(A or C),Dest ID,Dest row # A 10 1
567 IN 19 Gain
```

isc3_flex_sol.lin (Concept 3) Summer Solstice

```
* Controller for integrated symmetrical concentrator
system CONT1 18,9,9,0,0,0.0
-1 -1.4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 -1 -1.4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 -1 -1.4 0 0 0 0 0 0 0 0 0 0 0 0
\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & -1 & -1.4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{smallmatrix}
\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & -1.4 & 0 & 0 & 0 & 0 & 0 & 0 \end{smallmatrix}
0 0 0 0 0 0 0 0 0 0 0 0 0 -1 -1.4 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 -1 -1.4 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 -1 -1.4
*B
0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0
 0 0 0 0 0 0 0 0 0
 0 0 0 0 1 0 0 0 0
 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 1 0 0 0
 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 1 0 0
 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 1 0
 0 0 0 0 0 0 0 0 1
 .000025 .007 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 .000025 .007 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 .000025 .007 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 .0001 .014 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 .0001 .014 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0001 .014 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0001 .014 0 0 0 0
 *D
 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0
  0 0 0 0 0 0 0 0 0
  0 0 0 0 0 0 0 0 0
  0 0 0 0 0 0 0 0 0
  0 0 0 0 0 0 0 0 0
  *H
  * M
```

29 December 2000

los.dat (Concept 3) Summer Solstice

```
Defaults to sun as a target for zero input vector
               Defaults to sun as a target for zero input vector
                                                                                                                                                                            Target star along positive polar axis
                                      Target star along negative polar axis
                                                                                                                                    ! Sensor number of 2nd FGS (clamshell) sensor
! Sensor number of 1st FGS (clamshell) sensor
                                                                                                                                                                                                                       plane vector 2
                                                                                                                                                                                                         Focal plane vector 1
                                                                               Focal plane vector 2
                                                                                                   Focal plane vector 3
                                                                 Focal plane vector 1
                                                                                                                                                                                                                                            Focal plane vector
                                                                                                                                                                                                                              Focal
                                                                                                                                                               0.d0,0.d0,0.d0,
0.d0, 1.d0,0.d0,
0.d0,-1.d0,0.d0,
                                               0.d0, -1.d0,0.d0,
                                                                 0.d0,-1.d0,0.d0,
                                                                                                                                                                                                                                                  -1.d0,0.d0,0.d0
                                                                                      1.d0,0.d0,0.d0,
                            0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                 1.d0,0.d0,0.d0,
                                                                                                            1.d0,0.d0,0.d0
```

solar pressure.dat (Concept 3) Summer Solstice

```
.d0,0.d0, | body, node, area, reflectivity factor,outward normal,centroid | body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                              ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                       body, node, area, reflectivity factor, outward normal, centroid body, node, area, reflectivity factor, outward normal, centroid body, node, area, reflectivity factor, outward normal, centroid
                                                                                                                                                                           ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                           ! body, node, area, reflectivity factor, outward normal, centroid ! body, node, area, reflectivity factor, outward normal, centroid
                                                                                                                                                                                                                                                                                                                              ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                   ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            ! body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          body, node, area, reflectivity factor,outward normal,centroid body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    body, node, area, reflectivity factor,outward normal,centroid
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           body, node, area, reflectivity factor,outward normal,centroid
                                                                                                 ! body, node, area, reflectivity factor,outward normal,centroid ! body, node, area, reflectivity factor,outward normal,centroid
                           ! body, node, area, reflectivity factor,outward normal,centroid
                                                                ! body, node, area, reflectivity factor,outward normal,centroid
! number of panels, units English or Metric ***Updated 11/15/00***
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        2,4,785000.d0,0.0d0, -0.1736d0,-1.d0,0.9848d0,0.d0,0.d0,0.d0,
2,5,196000.d0,0.0d0, 1.d0,0.d0,0.d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              2,3,785000.d0,0.0d0, -0.1736d0,1.d0,-0.9848d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   2,4,785000.d0,0.0d0, 0.1736d0,0.d0,-0.9848d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                                                                                                                                                                                1,4,319000.d0,0.5d0,-1.d0,0.d0,0.d0,0.d0,0.d0,7.972d2, i bc
1,4,319000.d0,0.5d0,0.d0,-1.d0,0.d0,0.d0,0.d0,7.972d2, i bc
2,3,785000.d0,0.0d0, 0.1736d0,0.d0,0.9848d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                             1,3,319000.a0,0.5d0,-1.d0,0.d0,0.d0,0.d0,0.d0,0.d0,-7.972d2,1,3,319000.a0,0.5d0,0.d0,-1.d0,0.d0,0.d0,0.d0,0.d0,-7.972d2,1,4,319000.d0,0.5d0,1.d0,0.d0,0.d0,0.d0,0.d0,0.d0,7.972d2,1,4,319000.d0,0.5d0,1.d0,0.d0,1.d0,0.d0,0.d0,0.d0,7.972d2,
                                                                                                                                                                                                   1,3,319000.d0,0.5d0,1.d0,0.d0,0.d0,0.d0,0.d0,-7.972d2,1,3,319000.d0,0.5d0,0.d0,1.d0,0.d0,0.d0,0.d0,-7.972d2,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    2,5,196000.d0,0.0d0,-1.d0,0.d0,0.d0,0.d0,0.d0,0.d0,
                                                                                                                                1,2,638000.d0,0.5d0,-1.d0,0.d0,0.d0,0.d0,0.d0,0.d0,0.d0,
                                                    1,2,638000.d0,0.5d0,0.d0,-1.d0,0.d0,0.d0,0.d0,0.d0
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    3,2,1.04d7,1.0d0,0.d0,0.d0,-1.d0,0.d0,0.d0,0.d0,4,2,1.04d7,1.0d0,0.d0,0.d0,1.d0,0.d0,0.d0,0.d0,4,2,1.04d7,1.0d0,0.d0,0.d0,-1.d0,0.d0,0.d0,0.d0,0.d0,0.d0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               3,2,1.04d7,1.0d0,0.d0,0.d0,1.d0,0.d0,0.d0,0.d0,
```

isc3_flex_sol.flx (Concept 3) Summer Solstice (An excerpt)

```
flag, revision number
                      1
XXXXXX
  body id
         1
  modes, nodes, modal options
                                                                                         0
                                                       0
                                            0
                                0
                     4
        24
                                                                                         0
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 .51059035E-07 .57298172E-07 -.20698406E-13 -.54019335E-08
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 -.31119132E-06
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  .66271809E-06
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Contract No. NAS8-00151 Final Report

(and more)

isc3_flex_verneq.int (Concept 3) Vernal Equinox

TREETOPS REV 10P2 4/10/00

SIM CONTROL

1 SI 2 SI 3 SI 4 SI 5 SI 6 SI	<pre>0 Title 0 Simulation stop time 0 Plot data interval 0 Integration type (R,S,U, OR V) 0 Step size (sec) 0 Sandia ODE solver absolute and relative error</pre>	1000000 20 R .1	THIRD VERSION
7 SI 8 SI	0 RK78 ODE solver absolute error and first step size 0 Linearization option (L,Z or N)	N N	
9 SI 10 SI	0 Restart option (Y/N) 0 Contact force computation option (Y/N)	Y	
11 SI	O Constraint force computation option (1/N)	N A	
12 SI 13 SI	0 Mass matrix speedup option (All, Bypass, First, Nth) 0 Non-Linear speedup option (All, Bypass, First, Nth)	A A	
14 SI 15 SI 16 SI	O Constraint speedup option (All, Bypass, First, Neh) O Constraint stabilization option (Y/N)	A N	
17 SI	0 Stabilization epsilon		

GENGRAV

37	
18 GG 4 Gravity, earth sphere/nonsphere/user (S/N/U)? N	
19 GG 1 Input gravity constants: GME, ERAD, EMASS	
20 GG 1 Spherical or Nonspherical (S/N)?	
21 GG 1 Gravity Potential Harmonics J2, J3, J4 22 GG 4 English (ft-slug-s) or metric (m-kg-s) (E/M)? M	3 2020
22 CC 4 Day Month, Year,	
24 GG 4 GMT @ sim time 0 (minutes past midnight,	,,,
25 GG 4 Solar Pressure forces Y/N?	
26 GG 4 Input new data for aero model: (17N7	
27 GG 1 Solar flux F10 for aero model	
28 GG 1 Solar flux, 81 day average F10B	
29 GG 1 Geomagnetic index, GEAP	

BODY

		a a management	1
30	BO	1 Body ID number	F
31	BO	1 Type (Rigid, Flexible, NASTRAN)	24
32	BO	1 Number of modes	2
33	во	1 Modal calculation option (0, 1 or 2)	_
34	во	1 Foreshortening option (Y/N)	
35	ВО	1 Model reduction method (NO, MS, MC, CC, QM, CV)	
36	BO	1 NASTRAN data file FORTRAN unit number (40 - 60)	
37	BO	1 Number of augmented nodes (0 if none)	
38	BO	1 Damping matrix option (NS,CD,HL,SD)	
39	BO	1 Constant damping ratio	
40	BO	1 Low frequency, High frequency ratios	
41	во	1 Mode ID number, damping ratio	
42	BO	1 Conversion factors: Length, Mass, Force) 1
43	BO	1 Inertia reference node (0=Bdy Ref Frm; 1=mass cen	, -

Contract No. Bd Systems® NAS8-00151 Final Report TCD20000222A 29 December 2000 6.2852173E11 6.2852173E11 44 BO 1 Moments of inertia (kg-m2) Ixx,Iyy,Izz 45 BO 1 Products of inertia (kg-m2) Ixy,Ixz,Iyz 0 0 0 6.7057352E8 1.6168633E5 46 BO 1 Mass (kg) 1 Number of Nodes 1 Node ID, Node coord. (meters) x,y,z 1 0 0 0 47 BO 2 0 0 0 48 BO 49 BO 1 Node ID, Node coord. (meters) x,y,z 3 0 0 3188.8 1 Node ID, Node coord. (meters) x,y,z 4 0 0 -3188.8 51 BO 1 Node ID, Node coord. (meters) x,y,z 52 BO 1 Node ID, Node structual joint ID 50 BO 2 Body ID number 53 BO R 2 Type (Rigid, Flexible, NASTRAN) 54 BO 2 Number of modes 55 BO 2 Modal calculation option (0, 1 or 2) 57 BO 2 Foreshortening option (Y/N) 58 BO 2 Model reduction method (NO,MS,MC,CC,QM,CV) 56 BO 59 BO 2 NASTRAN data file FORTRAN unit number (40 - 60) 60 BO 2 Number of augmented nodes (0 if none) 61 BO 2 Damping matrix option (NS,CD,HL,SD) 62 BO 2 Constant damping ratio 63 BO 2 Low frequency, High frequency ratios 64 BO 2 Mode ID number, damping ratio 2 Conversion factors: Length, Mass, Force 66 BO 2 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 .8543E12 1.5601E12 67 BO 2 Moments of inertia (kg-m2) Ixx,Iyy,Izz 1.3822E12 0 0 0 68 BO 2 Products of inertia (kg-m2) Ixy, Ixz, Iyz 12666300 69 BO 2 Mass (kg) 70 BO 2 Number of Nodes 1 298.323 0 0 2 Node ID, Node coord. (meters) x,y,z 2 0 0 0 71 BO 72 BO 2 Node ID, Node coord. (meters) x,y,z 3 0 0 300 2 Node ID, Node coord. (meters) x,y,z 4 0 0 -300 73 BO 2 Node ID, Node coord. (meters) x,y,z 5 500 0 0 74 BO 2 Node ID, Node coord. (meters) x,y,z 75 BO 2 Node ID, Node structual joint ID 76 BO 3 Body ID number 3 Type (Rigid,Flexible,NASTRAN) 77 BO 78 BO 3 Number of modes 3 Modal calculation option (0, 1 or 2) 79 BO 80 BO 3 Foreshortening option (Y/N) 3 Model reduction method (NO, MS, MC, CC, QM, CV) 81 BO 3 NASTRAN data file FORTRAN unit number (40 - 60) 82 BO 83 BO 3 Number of augmented nodes (0 if none) 3 Damping matrix option (NS,CD,HL,SD) 84 BO 85 BO 3 Constant damping ratio 86 BO 87 BO 3 Low frequency, High frequency ratios 3 Mode ID number, damping ratio 88 BO 3 Conversion factors: Length, Mass, Force 3 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 89 BO 3 Moments of inertia (kg-m2) Ixx, Iyy, Izz 1.7E12 1.7E12 3.4E12 90 BO 91 BO 3 Products of inertia (kg-m2) Ixy, Ixz, Iyz 2046600 92 BO 93 BO 3 Mass (kg) 3 Number of Nodes 1 0 0 0 94 BO 3 Node ID, Node coord. (meters) x,y,z 95 BO 2 0 0 0 3 Node ID, Node coord. (meters) x,y,z 96 BO 3 Node ID, Node structual joint ID 97 BO 4 98 BO 4 Body ID number 99 BO 4 Type (Rigid, Flexible, NASTRAN) 100 BO 4 Number of modes 4 Modal calculation option (0, 1 or 2) 101 BO 102 BO 4 Foreshortening option (Y/N) 103 BO 4 Model reduction method (NO,MS,MC,CC,QM,CV) 4 NASTRAN data file FORTRAN unit number (40 - 60) 104 BO 4 Number of augmented nodes (0 if none) 105 BO 106 BO 4 Damping matrix option (NS,CD,HL,SD) 107 BO 4 Constant damping ratio 4 Low frequency, High frequency ratios 108 BO 4 Mode ID number, damping ratio

109 BO

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29 December 2000

175 HI 3 L3 unit vector in inboard body coord. x,y,z

176 HI 3 L3 unit vector in outboard body coord. x,y,z

177 HI 3 Thirial rotation angles (deg)

0 1 0
0 0 0 -135.
29 December 2000
 177 HI 3 Initial rotation angles (deg)
                                                                                                    -0.004178 0 0
 178 HI 3 Initial rotation rates (deg/sec)
179 HI 3 Rotation stiffness (newton-meters/rad)
                                                                                                     0 0 0
                                                                                                0 0 0
 180 HI 3 Rotation damping (newton-meters/rad/sec)
 180 HI 3 Rotation damping (Newton Moderate

181 HI 3 Null torque angles (deg)

182 HI 3 Number of translation DOFs

183 HI 3 First translation unit vector g1

184 HI 3 Second translation unit vector g2

Third translation unit vector g3
                                                                                                    1 0 0
                                                                                                   0 1 0
  185 HI 3 Third translation unit vector g3
186 HI 3 Initial translation (meters)
187 HI 3 Initial translation velocity (meters/sec)
                                                                                                    0 0 1
                                                                                                     0 0 0
  188 HI 3 Translation stiffness (newtons/meters)
189 HI 3 Translation damping (newtons/meter/sec)
190 HI 3 Null force translations
   191 HI 4 Hinge ID number
                                                                                                      1 4
                4 Inboard body ID, Outboard body ID
                                                                                                      4 2
   192 HI
              4 "p" node ID, "q" node ID
   193 HI
   194 HI 4 Number of rotation DOFs
   195 HI 4 L1 unit vector in inboard body coord. x,y,z
196 HI 4 L1 unit vector in outboard body coord. x,y,z
197 HI 4 L2 unit vector in inboard body coord. x,y,z
                                                                                                     0 0 1
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   198 HI 4 L2 unit vector in outboard body coord. x,y,z
   199 HI 4 L3 unit vector in inboard body coord. X,y,z 0 1 0 200 HI 4 L3 unit vector in outboard body coord. X,y,z 0 1 0 201 HI 4 Initial rotation angles (deg) 0. 0.
                                                                                                     0. 0. -45.
                                                                                                      -0.004178 0 0
   202 HI 4 Initial rotation rates (deg/sec)
203 HI 4 Rotation stiffness (newton-meters/rad)
204 HI 4 Rotation damping (newton-meters/rad/sec)
                                                                                                0 0 0
0 0 0
0 0 0
   204 HI 4 Rotation damping (newton meters)

205 HI 4 Null torque angles (deg)

206 HI 4 Number of translation DOFs

207 HI 4 First translation unit vector g1

208 HI 4 Second translation unit vector g2

209 HI 4 Third translation unit vector g3
                                                                                                     1 0 0
0 1 0
                                                                                                      0 0 1
    210 HI 4 Initial translation (meters)
211 HI 4 Initial translation velocity (meters/sec)
                                                                                                      0 0 0
    212 HI 4 Translation stiffness (newtons/meters)
    213 HI 4 Translation damping (newtons/meter/sec)
     214 HI 4 Null force translations
                      SENSOR
     216 SE 1 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ET
217 SF 1 Mounting point body ID Mounting point
                   1 Mounting point body ID, Mounting point node ID
     218 SE 1 Second mounting point body ID, Second node ID
     219 SE 1 Input axis unit vector (IA) x,y,z
     220 SE 1 Mounting point Hinge index, Axis index
221 SE 1 First focal plane unit vector (Fp1) x,y,z 0 1 0
222 SE 1 Second focal plane unit vector (Fp2) x,y,z 0 1 0
      223 SE 1 Sun/Star unit vector (Us) x,y,z
224 SE 1 Velocity Aberration Option (Y/N)
                   1 Velocity Aberration Option (Y/N)
      225 SE 1 Euler Angle Sequence (1-6)
      226 SE 1 CMG ID number and Gimbal number
                  1 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 6378000 0 0 4.178074D-3
      227 SE
                   2 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST
      228 SE
                    2 Mounting point body ID, Mounting point node ID
                                                                                                          2 2
      229 SE
                   2 Second mounting point body ID, Second node ID
      230 SE
      231 SE
      232 SE 2 Input axis unit vector (IA) x,y,z
      232 SE 2 Input axis unit vector (In) Axis index
233 SE 2 Mounting point Hinge index, Axis index
234 SE 2 First focal plane unit vector (Fp1) x,y,z
235 SE 2 Second focal plane unit vector (Fp2) x,y,z
                                                                                                         0 -1 0
                                                                                                          1 0 0
                                                                                                          0 1 0
       236 SE 2 Sun/Star unit vector (Us) x,y,z
237 SE 2 Velocity Aberration Option (Y/N)
                                                                                                          N
       238 SE 2 Euler Angle Sequence (1-6)
       239 SE 2 CMG ID number and Gimbal number
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29 December 2000 2 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 3 Sensor ID number 3 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) L 241 SE 242 SE 3 Mounting point body ID, Mounting point node ID 243 SE 3 Second mounting point body ID, Second node ID 244 SE 1 2 3 3 Input axis unit vector (IA) x,y,z 245 SE 3 Mounting point Hinge index, Axis index 246 SE 3 First focal plane unit vector (Fp1) x,y,z 247 SE 3 Second focal plane unit vector (Fp2) x,y,z 248 SE 3 Sun/Star unit vector (Us) x,y,z 249 SE 3 Velocity Aberration Option (Y/N) 250 SE 3 Euler Angle Sequence (1-6) 251 SE 3 CMG ID number and Gimbal number 3 Earth pt (rad,lat,lon,rotation [m/e, d, d, d/s]) 252 SE 253 SE 4 Sensor ID number 4 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) L 254 SE 255 SE 4 Mounting point body ID, Mounting point node ID 4 2 256 SE 4 Second mounting point body ID, Second node ID 257 SE 3 2 1 4 Input axis unit vector (IA) x,y,z 258 SE 4 Mounting point Hinge index, Axis index 259 SE 4 First focal plane unit vector (Fp1) x,y,z 4 Second focal plane unit vector (Fp2) x,y,z 260 SE 261 SE 4 Sun/Star unit vector (Us) x,y,z 262 SE 4 Velocity Aberration Option (Y/N) 263 SE 4 Euler Angle Sequence (1-6) 264 SE 4 CMG ID number and Gimbal number 265 SE 4 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 266 SE 5 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST 267 SE 5 Mounting point body ID, Mounting point node ID 268 SE 269 SE 5 Second mounting point body ID, Second node ID 270 SE 5 Input axis unit vector (IA) x,y,z 271 SE 5 Mounting point Hinge index, Axis index 272 SE 0 0 1 5 First focal plane unit vector (Fp1) x,y,z 273 SE 0 -1 0 5 Second focal plane unit vector (Fp2) x,y,z274 SE 0 0 0 5 Sun/Star unit vector (Us) x,y,z 275 SE 5 Velocity Aberration Option (Y/N) 276 SE 5 Euler Angle Sequence (1-6) 277 SE 278 SE 5 CMG ID number and Gimbal number 279 SE 5 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 6 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV A3 6 Sensor ID number 280 SE 6 Mounting point body ID, Mounting point node ID 281 SE 282 SE 6 Second mounting point body ID, Second node ID 283 SE 6 Input axis unit vector (IA) x,y,z 284 SE 6 Mounting point Hinge index, Axis index 285 SE 6 First focal plane unit vector (Fp1) x,y,z 286 SE 6 Second focal plane unit vector (Fp2) x,y,z 287 SE 6 Sun/Star unit vector (Us) x,y,z 288 SE 6 Velocity Aberration Option (Y/N) 289 SE 6 Euler Angle Sequence (1-6) 290 SE 6 CMG ID number and Gimbal number 291 SE 6 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 292 SE 7 Sensor ID number 7 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV AC 293 SE 294 SE 7 Mounting point body ID, Mounting point node ID 2 2 295 SE 7 Second mounting point body ID, Second node ID 296 SE 1 0 0 7 Input axis unit vector (IA) x,y,z 297 SE 7 Mounting point Hinge index, Axis index 298 SE 7 First focal plane unit vector (Fp1) x,y,z 7 Second focal plane unit vector (Fp2) x,y,z 299 SE 300 SE 7 Sun/Star unit vector (Us) x,y,z 301 SE 7 Velocity Aberration Option (\bar{Y}/N) 302 SE 7 Euler Angle Sequence (1-6) 303 SE 7 CMG ID number and Gimbal number 7 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 305 SE

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ACTR	
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a amount or ID number	MO
1 τ τι MO Π Β MΔ SG DG, W, LI, MI - M' / /	
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309 AC 1 Mounting point body ID second node ID	
310 AC 1 Second mounting point body 12,	0 1 0
310 AC 1 Second mounts with vector x,y,z 311 AC 1 Output axis unit vector x,y,z 312 AC 1 Mounting point Hinge index, Axis index	
313 AC 1 Rotor spin axis unit value in a friction (D, S, B, N)	
and e (ded), inertia, irrouter	
315 AC 1 Outer gimbal axis unit vector x,y,z 316 AC 1 Outer gimbal axis unit vector x,y,z 316 AC 1 Outer gimbal axis unit vector x,y,z	
316 AC 1 Outer gimbal axis unit vector x/y/ 317 AC 1 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 318 AC 1 Inner gimbal - angle(deg), inertia, friction(D,S,B,N)	
318 AC 1 Inner gimbal angle (deg), including 319 AC 1 Inner gimbal axis unit vector x,y,z 319 AC 1 Inner gimbal axis unit vector x,y,z	
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1, 1-1 longth and falle, yillor and i	
1 Congtants: KI Or WO, II of Zeca, As,	
322 AC 1 Constants, R1 32 323 AC 1 Non-linearities; TLim, Tco, Dz	
	2
324 AC 2 Actuator ID number	MO
325 AC 2 Type(J, H, MO, T, B, MA, SG, DG, W, E, MI CO H)	
	2 2
	0 0 1
	0 0 1
and a mounting point Hinge index, Axis index	
221 AC 2 Rotor spin axis unit vector X,Y/2	
331 AC 2 Motor specific momentum, H 332 AC 2 Initial rotor momentum, H 333 AC 2 Outer gimbal angle(deg), inertia, friction(D,S,B,N)	
333 AC 2 Outer gimbal angle(udg), thousand angle (udg), thousand a	
334 AC 2 Outer gimbal axis unit vector X/J , X/J (m, M, B, k) 335 AC 2 Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 335 AC 2 Out gim fric (Tfi, Tgfo, GAM) / inertial friction (D, S, B, N)	
a remain andle (ded), increase,	
336 AC 2 Inner gimbal axis unit vector x,y,z 337 AC 2 Inner gimbal axis unit vector x,y,z	
339 AC 2 Initial length and late, 1 and 1439, 340 AC 2 Constants; K1 or wo, n or zeta, Kg, Jm 341 AC 2 Non-linearities; TLim, Tco, Dz	
341 AC 2 Non-linearities, Ibin, 1997	2
342 AC 3 Actuator ID number	3 MO
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	2 2
344 AC 3 Actuator location; Node of Infig. 345 AC 3 Mounting point body ID number, node ID number 346 AC 3 Second mounting point body ID, second node ID	
346 AC 3 Second mounting point body 12, 347 AC 3 Output axis unit vector x,y,Z	1 0 0
a Maunting point Hinge Index, Axis Index	
240 MC 3 Rotor spin axis unit vector A, 7, 2	
350 AC 3 Initial rotor momentum, H	1)
351 AC 3 Outer gimbal- angle(deg), Thereta, Trooters	
351 AC 3 Outer gimbal axis unit vector x,y,z 352 AC 3 Outer gimbal axis unit vector x,y,z 353 AC 3 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,)	c)
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a r 'r' al longth and (ale, y) co/ com	
ac a Constants, Ki or wo, ii or zeca,	
359 AC 3 Non-linearities; TLim, Tco, Dz	
360 AC 4 Actuator ID number	4 MO
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A Cogord mounting point body in, because	1 0 0
364 AC 4 Second modulary 1 365 AC 4 Output axis unit vector x,y,z 366 AC 4 Mounting point Hinge index, Axis index	
	N)
368 AC 4 Initial rotor momentum, n 369 AC 4 Outer gimbal- angle(deg),inertia,friction(D,S,B,	IN /
202 110	

Bd Systems® TCD20000222A 29 December 2000 4 Outer gimbal axis unit vector x,y,z 4 Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 4 Inner gimbal- angle(deg), inertia, friction(D,S,B,N) 4 Inner gimbal axis unit vector x,y,z 4 In gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 373 AC 374 AC 4 Initial length and rate, y(to) and ydot(to) 375 AC 4 Constants; K1 or wo, n or zeta, Kg, Jm 376 AC 4 Non-linearities; TLim, Tco, Dz 377 AC 5 Actuator ID number 378 AC 5 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 379 AC 5 Actuator location; Node or Hinge (N or H) 380 AC 5 Mounting point body ID number, node ID number 3 2 381 AC 5 Second mounting point body ID, second node ID 382 AC 0 1 0 5 Output axis unit vector x,y,z 383 AC 5 Mounting point Hinge index, Axis index 384 AC 5 Rotor spin axis unit vector x,y,z 385 AC 5 Initial rotor momentum, H 386 AC 5 Outer gimbal- angle(deg), inertia, friction(D,S,B,N) 387 AC 5 Outer gimbal axis unit vector x,y,z 388 AC 5 Out gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k) 389 AC 5 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 390 AC 5 Inner gimbal axis unit vector x,y,z 391 AC 5 In gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 392 AC 5 Initial length and rate, y(to) and ydot(to) 393 AC 5 Constants; K1 or wo, n or zeta, Kg, Jm 394 AC 5 Non-linearities; TLim, Tco, Dz 395 AC 6 Actuator ID number 396 AC MO 6 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 397 AC 6 Actuator location; Node or Hinge (N or H) 398 AC 6 Mounting point body ID number, node ID number 3 2 399 AC 6 Second mounting point body ID, second node ID 400 AC 0 0 1 6 Output axis unit vector x,y,z 401 AC 6 Mounting point Hinge index, Axis index 402 AC 6 Rotor spin axis unit vector x,y,z403 AC 6 Initial rotor momentum, H 6 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 404 AC 405 AC 6 Outer gimbal axis unit vector x,y,z 406 AC 6 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 407 AC 6 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 408 AC 6 Inner gimbal axis unit vector x,y,z 409 AC 6 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 410 AC 6 Initial length and rate, y(to) and ydot(to) 411 AC 6 Constants; K1 or wo, n or zeta, Kg, Jm 412 AC 6 Non-linearities; TLim, Tco, Dz 413 AC 7 7 Actuator ID number 414 AC МО 7 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 415 AC 7 Actuator location; Node or Hinge (N or H) 416 AC 7 Mounting point body ID number, node ID number 4 2 417 AC 7 Second mounting point body ID, second node ID 418 AC 1 0 0 7 Output axis unit vector x,y,z419 AC 7 Mounting point Hinge index, Axis index 420 AC 7 Rotor spin axis unit vector x,y,z 421 AC 7 Initial rotor momentum, H 422 AC 7 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 423 AC 7 Outer gimbal axis unit vector x,y,z 7 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 424 AC 425 AC 7 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 426 AC 7 Inner gimbal axis unit vector x,y,z 427 AC 7 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 428 AC 7 Initial length and rate, y(to) and ydot(to) 429 AC 7 Constants; K1 or wo, n or zeta, Kg, Jm 430 AC 7 Non-linearities; TLim, Tco, Dz 431 AC 8 Actuator ID number 432 AC MO 8 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 433 AC 8 Actuator location; Node or Hinge (N or H) 434 AC

435 AC

436 AC

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Bd Systems® Contract No. NAS8-00151 TCD20000222A NAS8-00151 29 December 2000 437 AC 8 Output axis unit vector x,y,z 438 AC 8 Mounting point Hinge index, Axis index

1 CD20000222		
29 December 2	2000	1 0
437 AC 8	Output axis unit vector x,y,z Mounting point Hinge index, Axis index	
	Rotor spin axis unit vector x,y,z	
_	- iti-1 -atox momentum H	
440 AC 8	Outer gimbal- angle(deg), inertia, friction(D, S, B, N)	
_	a	
444 30 9	Inner gimbal - angle (deg), inertia, ilittion(b,b,b,b,m)	
	To gim fric (Tfi. Tgio, GAM)/(Tii, M, D, Ri// (M, M, D, C)	
442 30 0	Initial length and rate, y(to) and ydoctor	
449 30 8	Constants: K1 or wo, n or zeta, kg, om	
449 AC 8	Non-linearities; TLim, Tco, Dz	
		9
450 AC 9	Actuator ID number	MO
451 AC 9	Type (J, H, MO, T, B, MA, SG, DG, W, L, M1-M7, US)	
452 AC 9	Actuator location; Node or Hinge (N or H) Mounting point body ID number, node ID number	4 2
453 AC 9	Mounting point body ID number, had be second mounting point body ID, second node ID	
454 AC 9	Output axis unit vector x, y, z	0 0 1
455 AC 9	Mounting point Hinge index, Axis index	
	Rotor spin axis unit vector x,y,z	
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450 40 0	Outer gimbal- angle(deg), inertia, iriction(b, 5, 5, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10	
	a	
	folia (mfi mafo GAMI/(TII,M,D,AI//(M,A,D,AI/	
462 30 9	Inner gimbal- angle(deg), inertia, iffection(b, b, b, b, m,	
	rooms wimbal axid unit Vector X, Y, 4	
	The sime frice (Tfi Tafo.GAM)/(Til,M,D,Ki)/(M,M,D,K)	
465 AC 9	Initial length and rate, y(to) and ydot(to)	
466 AC 9	Constants; K1 or wo, n or zeta, Kg, Jm	
467 AC 9	Non-linearities; TLim, Tco, Dz	
	The number	10
468 AC 10	Actuator ID number Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US)	J
	Naturator location: Node of Hinge (N of H)	
	securities point body III number, node in name	2 5
471 AC 10 472 AC 10	Second mounting point body ID, second node ID	1 0 0
	Noutenat avia unit vector X, Y, Z	-1 0 0
474 NO 10	Mounting point Hinge index, AXIS Index	
475 AC 10	Rotor spin axis unit vector x,y,2	
	· · · 1 momonfilm H	
477 30 16	n Outer gimbal- angle(deg), inertia, illetion(b, b, b, b, m,	
	a a wimbal avid imir Vectur A.y.4	
479 AC 10	O Outer gimbal axis unit of the gimbal axis unit of the gimbal axis unit of the gimbal	
	O Inner gimbal axis unit vector x, y, z O Inner gimbal axis unit vector x, y, z	
481 AC 10	O Inner gimbar axis unit voor (Tfi,M,D,Kf)/(m,M,B,k) O In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)	
482 AC 10	0 In gim life (111,1520, but of the life (111),1520, but o	
483 AC 19	O Constants; K1 or wo, n or zeta, Kg, Jm	
485 AC 1	0 Non-linearities; TLim, Tco, Dz	
400 40 1		
	CONTROLLER	
		1
486 CO	1 Controller ID number	CM
487 CO	1 Controller type (CB,CM,DB,DM,UC,UD)	
488 CO	1 Sample time (sec) 1 Number of inputs, Number of outputs	9 9
	1 Number of states	
	1 Output No., Input type (I,S,T), Input ID, Gain	
491 CO	1 Odepac No.7 Impac off	
	INTERCONNECT	
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492 IN	1 Interconnect ID number	s 1 1
493 IN	1 Courge type(S.C. or F), Source ID, Source IOW #	C 1 1
494 IN	1 Destination type(A or C), Dest 10, Dest 10.	4.41E13
495 IN	1 Gain	
106 731	2 Interconnect ID number	2
496 IN	Z Interconnece 12 man	

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29 December 2000 497 IN 2 Source type(S,C, or F),Source ID,Source row # 498 IN 2 Destination type(A or C),Dest ID,Dest row # 499 IN 2 Gain	C 1 1 A 1 1 1
500 IN 3 Interconnect ID number 501 IN 3 Source type(S,C, or F), Source ID, Source row # 502 IN 3 Destination type(A or C), Dest ID, Dest row # 503 IN 3 Gain	3 S 1 2 C 1 2 1.67E12
504 IN 4 Interconnect ID number 505 IN 4 Source type(S,C, or F), Source ID, Source row # 506 IN 4 Destination type(A or C), Dest ID, Dest row # 507 IN 4 Gain	4 C 1 2 A 2 1
508 IN 5 Interconnect ID number 509 IN 5 Source type(S,C, or F),Source ID,Source row # 510 IN 5 Destination type(A or C),Dest ID,Dest row # 511 IN 5 Gain	5 S 2 1 C 1 3 4.31E13
512 IN 6 Interconnect ID number 513 IN 6 Source type(S,C, or F),Source ID,Source row # 514 IN 6 Destination type(A or C),Dest ID,Dest row # 515 IN 6 Gain	6 C 1 3 A 3 1
516 IN 7 Interconnect ID number 517 IN 7 Source type(S,C, or F),Source ID,Source row # 518 IN 7 Destination type(A or C),Dest ID,Dest row # 519 IN 7 Gain	7 S 3 1 C 1 4 1.7E12
520 IN 8 Interconnect ID number 521 IN 8 Source type(S,C, or F),Source ID,Source row # 522 IN 8 Destination type(A or C),Dest ID,Dest row # 523 IN 8 Gain	8 C 1 4 A 4 1 1
524 IN 9 Interconnect ID number 525 IN 9 Source type(S,C, or F),Source ID,Source row # 526 IN 9 Destination type(A or C),Dest ID,Dest row # 527 IN 9 Gain	9 S 3 2 C 1 5 1.7E12
528 IN 10 Interconnect ID number 529 IN 10 Source type(S,C, or F), Source ID, Source row # 530 IN 10 Destination type(A or C), Dest ID, Dest row # 531 IN 10 Gain	10 C 1 5 A 5 1 1
532 IN 11 Interconnect ID number 533 IN 11 Source type(S,C, or F), Source ID, Source row # 534 IN 11 Destination type(A or C), Dest ID, Dest row # 535 IN 11 Gain	11 S 3 3 C 1 6 3.4E12
536 IN 12 Interconnect ID number 537 IN 12 Source type(S,C, or F),Source ID,Source row # 538 IN 12 Destination type(A or C),Dest ID,Dest row # 539 IN 12 Gain	12 C 1 6 A 6 1 1
540 IN 13 Interconnect ID number 541 IN 13 Source type(S,C, or F),Source ID,Source row # 542 IN 13 Destination type(A or C),Dest ID,Dest row # 543 IN 13 Gain	13 S 4 1 C 1 7 1.7E12
544 IN 14 Interconnect ID number 545 IN 14 Source type(S,C, or F),Source ID,Source row # 546 IN 14 Destination type(A or C),Dest ID,Dest row # 547 IN 14 Gain	14 C 1 7 A 7 1 1
548 IN 15 Interconnect ID number 549 IN 15 Source type(S,C, or F),Source ID,Source row # 550 IN 15 Destination type(A or C),Dest ID,Dest row # 551 IN 15 Gain	15 S 4 2 C 1 8 1.7E12
552 IN 16 Interconnect ID number 553 IN 16 Source type(S,C, or F),Source ID,Source row #	16 C 1 8

Contract No. Bd Systems® NAS8-00151 TCD20000222A Final Report 29 December 2000 554 IN 16 Destination type(A or C), Dest ID, Dest row # A 8 1 1 555 IN 16 Gain 17 556 IN 17 Interconnect ID number 557 IN 17 Source type(S,C, or F), Source ID, Source row # s 4 3 558 IN 17 Destination type(A or C), Dest ID, Dest row # C 1 9 3.4E12 559 IN 17 Gain 18 560 IN 18 Interconnect ID number C 1 9 561 IN 18 Source type(S,C, or F),Source ID,Source row # 562 IN 18 Destination type(A or C),Dest ID,Dest row # A 9 1 1 563 IN 18 Gain 19 564 IN 19 Interconnect ID number 565 IN 19 Source type(S,C, or F),Source ID,Source row # s 5 3 566 IN 19 Destination type(A or C), Dest ID, Dest row # A 10 1 567 IN 19 Gain

isc3_flex_autmeq.int (Concept 3) Autumnal Equinox

TREETOPS REV 10P2 4/10/00

SIM CONTROL

1	ST	0 Title	ISC MODEL,	THIRD	VERSION
2	SI	0 Simulation stop time	20		
_	SI SI	0 Plot data interval 0 Integration type (R,S,U, OR V)	R		
_		0 Ston size (SeC)	. 1		
-		O Sandia ODE solver absolute and relative error O RK78 ODE solver absolute error and first step size			
	SI SI	0 Linearization option (L,Z or N)	N N		
~	SI	n Restart option (Y/N)	Y		
	SI SI	O Contact force computation option (Y/N)	N		
	SI	a g 11 angle speedup option (All, Bypass, First, Neil)	A A		
	SI	0 Small angle speedup option (All, Bypass, First, Nth) 0 Mass matrix speedup option (All, Bypass, First, Nth) 0 Non-Linear speedup option (All, Bypass, First, Nth)	A		
	SI SI	O Constraint speedup option (All, Bypass, First, Ntm)	A		
16	SI SI	0 Constraint stabilization option (Y/N) 0 Stabilization epsilon	N		

GENGRAV

18 GG 19 GG 20 GG	4 Gravity, earth sphere/nonsphere/user (S/N/U)? 1 Input gravity constants: GME, ERAD, EMASS 1 Spherical or Nonspherical (S/N)? 1 Gravity Potential Harmonics J2,J3,J4	N
21 GG	1 Gravity Potential harmonies of (m-kg-s) (E/M)?	M
22 GG	4 English (ft-slug-s) or metric (m-kg-s) (E/M)?	20 9 2020
23 GG	4 Day, Month, Year,	360
24 GG	4 GMT @ sim time 0 (minutes past midnight,	Y
25 GG	4 Solar Pressure forces Y/N?	N
26 GG	4 Input new data for aero model? (Y/N)	
27 GG	1 Solar flux F10 for aero model	
28 GG	1 Solar flux, 81 day average F10B	
29 GG	1 Geomagnetic index, GEAP	

BODY

31 BO	1 Body ID number 1 Type (Rigid,Flexible,NASTRAN) 1 Number of modes	1 F 24
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Contract No. NAS8-00151 Bd Systems® TCD20000222A Final Report 29 December 2000 33 BO 1 Modal calculation option (0, 1 or 2) 34 BO 1 Foreshortening option (Y/N) 1 Model reduction method (NO,MS,MC,CC,QM,CV) 36 BO 1 NASTRAN data file FORTRAN unit number (40 - 60) 37 BO 1 Number of augmented nodes (0 if none) 38 BO 1 Damping matrix option (NS,CD,HL,SD) 39 BO 1 Constant damping ratio 40 BO 1 Low frequency, High frequency ratios 41 BO 1 Mode ID number, damping ratio 1 Conversion factors: Length, Mass, Force 42 BO 1 Conversion factors: Length, Mass, Force
43 BO 1 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 6.2852173E11 6.2852173E11 44 BO 1 Moments of inertia (kg-m2) Ixx, Iyy, Izz 6.7057352E8 45 BO 1 Products of inertia (kg-m2) Ixy,Ixz,Iyz 46 BO 1 Mass (kg) 0 0 0 1.6168633E5 47 BO 1 Number of Nodes 1 0 0 0 48 BO 1 Node ID, Node coord. (meters) x,y,z 2 0 0 0 1 Node ID, Node coord. (meters) x,y,z 50 BO 1 Node ID, Node coord. (meters) x,y,z
51 BO 1 Node ID, Node coord. (meters) x,y,z
52 BO 1 Node ID, Node coord. (meters) x,y,z
53 BO 1 Node ID, Node structual joint ID 3 0 0 3188.8 4 0 0 -3188.8 2 2 Body ID number 53 BO 2 Type (Rigid, Flexible, NASTRAN) 54 BO 2 Number of modes 55 BO 2 Modal calculation option (0, 1 or 2) 56 BO 2 Foreshortening option (Y/N) 2 Model reduction method (NO, MS, MC, CC, QM, CV) 57 BO 2 NASTRAN data file FORTRAN unit number (40 - 60) 58 BO 59 BO 2 Number of augmented nodes (0 if none) 60 BO 2 Damping matrix option (NS,CD,HL,SD) 61 BO 2 Constant damping ratio 62 BO 2 Low frequency, High frequency ratios 63 BO 2 Mode ID number, damping ratio 2 Conversion factors: Length, Mass, Force 64 BO 2 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 65 BO .8543E12 1.5601E12 66 BO 2 Moments of inertia (kg-m2) Ixx, Iyy, Izz 67 BO 1.3822E12 68 BO 2 Products of inertia (kg-m2) Ixy,Ixz,Iyz 69 BO 2 Mass (kg) 0.0.0 12666300 2 Number of Nodes 1 298.323 0 0 70 BO 2 Node ID, Node coord. (meters) x,y,z 71 BO 2 0 0 0 2 Node ID, Node coord. (meters) x,y,z 72 BO 3 0 0 300 2 Node ID, Node coord. (meters) x,y,z 4 0 0 -300 5 500 0 0 73 BO 2 Node ID, Node coord. (meters) x,y,z 74 BO 2 Node ID, Node coord. (meters) x,y,z 75 BO 2 Node ID, Node structual joint ID 76 BO 3 3 Body ID number 77 BO R 3 Type (Rigid, Flexible, NASTRAN) 79 BO 3 Number of modes 80 BO 3 Modal calculation option (0, 1 or 2) 81 BO 3 Foreshortening option (Y/N) 82 BO 3 Model reduction method (NO,MS,MC,CC,QM,CV) 83 BO 3 NASTRAN data file FORTRAN unit number (40 - 60) 84 BO 3 Number of augmented nodes (0 if none) 3 Damping matrix option (NS,CD,HL,SD) 85 BO 86 BO 3 Constant damping ratio 87 BO 3 Low frequency, High frequency ratios 3 Mode ID number, damping ratio 88 BO 3 Conversion factors: Length, Mass, Force 89 BO 3 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 3 Moments of inertia (kg-m2) Ixx, Iyy, Izz 1.7E12 1.7E12 3.4E12 3 Products of inertia (kg-m2) Ixy, Ixz, Iyz 0 0 0 90 BO 91 BO 92 BO 2046600 3 Mass (kg) 93 BO 3 Number of Nodes 94 BO 1 0 0 0 3 Node ID, Node coord. (meters) x,y,z 95 BO 2 0 0 0 3 Node ID, Node coord. (meters) x,y,z 96 BO 3 Node ID, Node structual joint ID 97 BO 4 Body ID number 98 BO

Bd Systems® NAS8-00151 TCD20000222A Final Report 29 December 2000 R 99 BO 4 Type (Rigid, Flexible, NASTRAN) 100 BO 4 Number of modes 101 BO 4 Modal calculatio 101 BO 4 Modal calculation option (0, 1 or 2) 102 BO 4 Foreshortening option (Y/N) 103 BO 4 Model reduction method (NO,MS,MC,CC,QM,CV) 104 BO 4 NASTRAN data file FORTRAN unit number (40 - 60) 105 BO 4 Number of augmented nodes (0 if none) 106 BO 4 Damping matrix option (NS,CD,HL,SD) 107 BO 4 Constant damping ratio 108 BO 4 Low frequency, High frequency ratios 109 BO 4 Mode ID number, damping ratio 4 Conversion factors: Length, Mass, Force 111 BO 4 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
112 BO 4 Moments of inertia (kg-m2) Ixx,Iyy,Izz 1.7E12 1.7E12 3.4E12
113 BO 4 Products of inertia (kg-m2) Ixy,Ixz,Iyz 0 0 0 2046600 114 BO 4 Mass (kg) 115 BO 4 Number of Nodes 116 BO 4 Node ID, Node coord. (meters) x,y,z 117 BO 4 Node ID, Node coord. (meters) x,y,z 1 0 0 0 2 0 0 0 118 BO 4 Node ID, Node structual joint ID HINGE 1 Hinge ID number 119 HI 0 1 1 Inboard body ID, Outboard body ID 120 HI 121 HI 1 "p" node ID, "q" node ID 122 HI 1 Number of rotation DOFs, Rotation option (F or G)
123 HI 1 L1 unit vector in inboard body coord. x,y,z 124 HI 1 L1 unit vector in outboard body coord. x,y,z 125 HI 1 L2 unit vector in inboard body coord. x,y,z 126 HI 1 L2 unit vector in outboard body coord. x,y,z 127 HI 1 L3 unit vector in inboard body coord. x,y,z 126 HI 1 L2 unit vector in oddboard body coord. x,y,z 0 0 1 127 HI 1 L3 unit vector in inboard body coord. x,y,z 0 0 1 128 HI 1 L3 unit vector in outboard body coord. x,y,z 0 0 0 1 -90 0 90 0 0 1 129 HI 1 Initial rotation angles (deg) 0 0 0.00417807 1 Initial rotation rates (deg/sec) 130 HI 1 Initial rotation rates (deg/sec)
131 HI 1 Rotation stiffness (newton-meters/rad) 0 0 0 0 0 0 0 0 0 131 HI 1 Rotation stiffness (newton-meters/rad)
132 HI 1 Rotation damping (newton-meters/rad/sec) 133 HI 1 Null torque angles (deg)
134 HI 1 Number of translation DOFs 135 HI 1 First translation unit vector g1
136 HI 1 Second translation unit vector g2
137 HI 1 Third translation unit vector g3
138 HI 1 Initial translation (meters) 1 0 0 0 1 0 0 0 1 137 HI 1 Third translation unit vector 138 HI 1 Initial translation (meters) 0 0 42163421 3074.681 0 0 0 0 0 139 HI 1 Initial translation velocity (meters/sec) 140 HI 1 Translation stiffness (newtons/meters) 0 0 0 1 Translation damping (newtons/meter/sec) 141 HI 1 Translation damping (new 142 HI 1 Null force translations 0 0 0 143 HI 2 Hinge ID number

144 HI 2 Inboard body ID, Outboard body ID

12

145 HI 2 "p" node ID, "q" node ID

146 HI 2 Number of rotation DOFs

147 HI 2 L1 unit vector in inboard body coord. x,y,z

148 HI 2 L1 unit vector in outboard body coord. x,y,z 149 HI 2 L2 unit vector in inboard body coord. x,y,z 150 HI 2 L2 unit vector in outboard body coord. x,y,z 151 HI 2 L3 unit vector in inboard body coord. x,y,z 1 0 0 152 HI 2 L3 unit vector in outboard body coord. x,y,z 0 0 0 153 HI 2 Initial rotation angles (deg) 154 HI 2 Initial rotation rates (deg/sec) 155 HI 2 Rotation stiffness (newton-meters/rad) 156 HI 2 Rotation damping (newton-meters/rad/sec) 157 HI 2 Null torque angles (deg) 158 HI 2 Number of translation DOFs 0 159 HI 2 First translation unit vector g1 0 1 0 160 HI 2 Second translation unit vector g2
161 HI 2 Third translation unit vector g3 0 0 1 0 0 0 162 HI 2 Initial translation (meters) 163 HI 2 Initial translation velocity (meters/sec) 164 HI 2 Translation stiffness (newtons/meters)

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Contract No. NAS8-00151 Bd Systems® TCD20000222A Final Report 29 December 2000 2 Translation damping (newtons/meter/sec) 2 Null force translations 167 HI 3 Hinge ID number 168 HI 3 Inboard body ID, Outboard body ID 169 HI 3 "p" node ID, "q" node ID 170 HI 3 Number of rotation DOFs 3 1/0 HI 3 Number of focation bods 171 HI 3 L1 unit vector in inboard body coord. x,y,z 0 0 1 172 HI 3 L1 unit vector in outboard body coord. x,y,z 0 0 1 173 HI 3 L2 unit vector in inboard body coord. x,y,z
174 HI 3 L2 unit vector in outboard body coord. 3 L2 unit vector in outboard body coord. x,y,z 175 HI 3 L3 unit vector in inboard body coord. x,y,z 0 1 0 176 HI 3 L3 unit vector in outboard body coord. x,y,z 0 1 0 180. 0 -135. 177 HI 3 Initial rotation angles (deg) 178 HI 3 Initial rotation rates (deg/sec) -0.004178 0 0 179 HI 3 Rotation stiffness (newton-meters/rad) 0 0 0 180 HI 3 Rotation damping (newton-meters/rad/sec) 0 0 0 0 0 0 3 Null torque angles (deg) 181 HI 3 Null torque angles (deg) 182 HI 3 Number of translation DOFs 1 0 0 183 HI 3 First translation unit vector gl 0 1 0 184 HI 3 Second translation unit vector g2 185 HI 3 Third translation unit vector g3 0 0 1 0 0 0 186 HI 3 Initial translation (meters) 187 HI 3 Initial translation velocity (meters/sec) 3 Translation stiffness (newtons/meters)
3 Translation damping (newtons/meter/sec) 188 HI 189 HI 190 HI 3 Null force translations 4 Hinge ID number 191 HI 1 4 192 HI 4 Inboard body ID, Outboard body ID 193 HI 4 "p" node ID, "q" node ID 4 2 194 HI 4 Number of rotation DOFs
195 HI 4 L1 unit vector in inboard body coord. x,y,z 0 0 1 196 HI 4 L1 unit vector in outboard body coord. x,y,z 0 0 1 197 HI 4 L2 unit vector in inboard body coord. x,y,z 198 HI 4 L2 unit vector in outboard body coord. x,y,z 199 HI 4 L3 unit vector in inboard body coord. x,y,z 0 1 0 200 HI 4 L3 unit vector in outboard body coord. x,y,z 0 1 0 180. 0 -45. 201 HI 4 Initial rotation angles (deg) -0.004178 0 0 4 Initial rotation rates (deg/sec) 202 HI 203 HI 4 Rotation stiffness (newton-meters/rad) 204 HI 4 Rotation damping (newton-meters/rad/sec) 0 0 0 0 0 0 205 HI 4 Null torque angles (deg) 206 HI 4 Number of translation DOFs 0 1 0 0 207 HI 4 First translation unit vector gl 0 1 0 208 HI 4 Second translation unit vector g2
209 HI 4 Third translation unit vector g3 209 HI 4 Third translation unit vector g3 210 HI 4 Initial translation (meters) 0 0 1 0 0 0 211 HI 4 Initial translation velocity (meters/sec) 212 HI 4 Translation stiffness (newtons/meters)
213 HI 4 Translation damping (newtons/meter/sec) 214 HI 4 Null force translations SENSOR 1 Sensor ID number 1 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ET 215 SE 1 Mounting point body ID, Mounting point node ID 216 SE 1 Second mounting point body ID, Second node ID 218 SE 1 Input axis unit vector (IA) x,y,z 219 SE 1 Mounting point Hinge index, Axis index 1 First focal plane unit vector (Fp1) x,y,z 1 Second focal plane unit vector (Fp2) x,y,z 1 Sun/Star unit vector (Us) x,y,z 220 SE 0 0 -1 221 SE 0 1 0 222 SE 223 SE 224 SE 1 Velocity Aberration Option (Y/N) 1 Euler Angle Sequence (1-6) 225 SE 1 CMG ID number and Gimbal number 227 SE 1 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 6378000 0 0 4.178074D-3 2 228 SE 2 Sensor ID number

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2 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST
       2 Mounting point body ID, Mounting point node ID
        2 Second mounting point body ID, Second node ID
         2 Input axis unit vector (IA) x,y,z
233 SE 2 Mounting point Hinge index, Axis index
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234 SE 2 First focal plane unit vector (Fp1) x,y,z
        2 Second focal plane unit vector (Fp2) x,y,z
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235 SE
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        2 Sun/Star unit vector (Us) x,y,z
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        2 Velocity Aberration Option (Y/N)
237 SE
        2 Euler Angle Sequence (1-6)
238 SE
         2 CMG ID number and Gimbal number
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        2 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
240 SE
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         3 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET)
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         3 Mounting point Hinge index, Axis index
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         3 First focal plane unit vector (Fp1) x,y,z
247 SE
        3 Second focal plane unit vector (Fp2) x,y,z
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         3 Sun/Star unit vector (Us) x,y,z
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        3 Velocity Aberration Option (Y/N)
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 255 SE
         4 Mounting point body ID, Mounting point node ID
 256 SE
          4 Second mounting point body ID, Second node ID
 257 SE
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         4 Input axis unit vector (IA) x,y,z
          4 Mounting point Hinge index, Axis index
 258 SE
 259 SE
         4 First focal plane unit vector (Fp1) x,y,z
 260 SE
         4 Second focal plane unit vector (Fp2) x,y,z
 261 SE
          4 Sun/Star unit vector (Us) x,y,z
 262 SE
         4 Velocity Aberration Option (Y/N)
 263 SE
         4 Euler Angle Sequence (1-6)
 264 SE
         4 CMG ID number and Gimbal number
          4 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
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          5 Sensor ID number
          5 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST
 268 SE
          5 Mounting point body ID, Mounting point node ID
          5 Second mounting point body ID, Second node ID
 269 SE
 270 SE
          5 Input axis unit vector (IA) x,y,z
           5 Mounting point Hinge index, Axis index
  272 SE
          5 First focal plane unit vector (Fp1) x,y,z
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  273 SE
          5 Second focal plane unit vector (Fp2) x,y,z
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  274 SE
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          5 Sun/Star unit vector (Us) x,y,z
5 Velocity Aberration Option (Y/N)
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          5 Euler Angle Sequence (1-6)
  277 SE
          5 CMG ID number and Gimbal number
  278 SE
          5 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
  279 SE
          6 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV A3
  280 SE
          6 Mounting point body ID, Mounting point node ID
  281 SE
          6 Second mounting point body ID, Second node ID
  283 SE
          6 Input axis unit vector (IA) x,y,z
           6 Mounting point Hinge index, Axis index
  285 SE
          6 First focal plane unit vector (Fp1) x,y,z
          6 Second focal plane unit vector (Fp2) x,y,z
  286 SE
  287 SE
          6 Sun/Star unit vector (Us) x,y,z
6 Velocity Aberration Option (Y/N)
  288 SE
  289 SE
          6 Euler Angle Sequence (1-6)
  290 SE
  291 SE 6 CMG ID number and Gimbal number
           6 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s])
  292 SE
            7 Sensor ID number
           7 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV AC
   294 SE
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Bd Systems® TCD20000222A 29 December 2000 7 Mounting point body ID, Mounting point node ID 7 Second mounting point body ID, Second node ID 1 0 0 7 Input axis unit vector (IA) x,y,z 7 Mounting point Hinge index, Axis index 298 SE 7 First focal plane unit vector (Fp1) x,y,z 299 SE 7 Second focal plane unit vector (Fp2) x,y,z 300 SE 7 Sun/Star unit vector (Us) x,y,z 301 SE 7 Velocity Aberration Option (Y/N) 302 SE 7 Euler Angle Sequence (1-6) 303 SE 7 CMG ID number and Gimbal number 304 SE 7 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 305 SE ACTR 1 1 Actuator ID number 306 AC 1 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) MO 307 AC 1 Actuator location; Node or Hinge (N or H) 308 AC 2 2 1 Mounting point body ID number, node ID number 1 Second mounting point body ID, second node ID 309 AC 310 AC 0 1 0 1 Output axis unit vector x,y,z 311 AC 1 Mounting point Hinge index, Axis index 312 AC 1 Rotor spin axis unit vector x,y,z 313 AC 1 Initial rotor momentum, H 1 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 314 AC 315 AC 1 Outer gimbal axis unit vector x,y,z 1 Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 316 AC 317 AC 1 Inner gimbal- angle(deg), inertia, friction(D,S,B,N) 318 AC 1 Inner gimbal axis unit vector x,y,z 1 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 319 AC 320 AC 1 Initial length and rate, y(to) and ydot(to) 321 AC 1 Constants; K1 or wo, n or zeta, Kg, Jm 322 AC 1 Non-linearities; TLim, Tco, Dz 323 AC 2 Actuator ID number 324 AC 2 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 2 Actuator location; Node or Hinge (N or H) 325 AC 326 AC 2 Mounting point body ID number, node ID number 2 2 327 AC 2 Second mounting point body ID, second node ID 0 0 1 328 AC 2 Output axis unit vector x,y,z 329 AC 2 Mounting point Hinge index, Axis index 330 AC 2 Rotor spin axis unit vector x,y,z 331 AC 2 Initial rotor momentum, H 2 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 332 AC 333 AC 2 Outer gimbal axis unit vector x,y,z 2 Out gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k) 334 AC 2 Inner gimbal- angle(deg), inertia, friction(D,S,B,N) 335 AC 336 AC 2 Inner gimbal axis unit vector x,y,z 2 In gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k) 337 AC 338 AC 2 Initial length and rate, y(to) and ydot(to) 339 AC 2 Constants; K1 or wo, n or zeta, Kg, Jm 340 AC 2 Non-linearities; TLim, Tco, Dz 341 AC 3 Actuator ID number 342 AC MO 3 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 343 AC 3 Actuator location; Node or Hinge (N or H) 344 AC 3 Mounting point body ID number, node ID number 2 2 3 Second mounting point body ID, second node ID 345 AC 346 AC 1 0 0 3 Output axis unit vector x,y,z 347 AC 3 Mounting point Hinge index, Axis index 348 AC 3 Rotor spin axis unit vector x,y,z 349 AC 3 Initial rotor momentum, H 3 Outer gimbal- angle(deg), inertia, friction(D,S,B,N) 350 AC 351 AC 3 Outer gimbal axis unit vector x,y,z 3 Out gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 352 AC 3 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 353 AC 354 AC 3 Inner gimbal axis unit vector x,y,z 3 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 355 AC 356 AC 3 Initial length and rate, y(to) and ydot(to)357 AC 3 Constants; K1 or wo, n or zeta, Kg, Jm 358 AC 3 Non-linearities; TLim, Tco, Dz 359 AC

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360 AC 4 Actuator ID number 361 AC 4 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 362 AC 4 Actuator location; Node or Hinge (N or H) 363 AC 4 Mounting point body ID number, node ID number 364 AC 4 Second mounting point body ID, second node ID 365 AC 4 Output axis unit vector x,y,Z 366 AC 4 Mounting point Hinge index, Axis index 367 AC 4 Rotor spin axis unit vector x,y,Z 368 AC 4 Initial rotor momentum, H 369 AC 4 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 370 AC 4 Outer gimbal axis unit vector x,y,Z 371 AC 4 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 372 AC 4 Inner gimbal axis unit vector x,y,Z 373 AC 4 Inner gimbal axis unit vector x,y,Z 374 AC 4 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 375 AC 4 Initial length and rate, y(to) and ydot(to) 376 AC 4 Constants; K1 or wo, n or zeta, Kg, Jm 377 AC 4 Non-linearities; TLim, Tco, Dz	4 MO 3 2 1 0 0
378 AC 5 Actuator ID number 379 AC 5 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 380 AC 5 Actuator location; Node or Hinge (N or H) 381 AC 5 Mounting point body ID number, node ID number 382 AC 5 Second mounting point body ID, second node ID 383 AC 5 Output axis unit vector x,y,z 384 AC 5 Mounting point Hinge index, Axis index 385 AC 5 Rotor spin axis unit vector x,y,z 386 AC 5 Initial rotor momentum, H 387 AC 5 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 388 AC 5 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 390 AC 5 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 391 AC 5 Inner gimbal axis unit vector x,y,z 392 AC 5 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 393 AC 5 Initial length and rate, y(to) and ydot(to) 394 AC 5 Constants; K1 or wo, n or zeta, Kg, Jm 395 AC 5 Non-linearities; TLim, Tco, Dz)
396 AC 6 Actuator ID number 397 AC 6 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 398 AC 6 Actuator location; Node or Hinge (N or H) 399 AC 6 Mounting point body ID number, node ID number 400 AC 6 Second mounting point body ID, second node ID 401 AC 6 Output axis unit vector x,y,z 402 AC 6 Mounting point Hinge index, Axis index 403 AC 6 Rotor spin axis unit vector x,y,z 404 AC 6 Initial rotor momentum, H 405 AC 6 Outer gimbal- angle(deg), inertia, friction(D,S,B,I) 406 AC 6 Outer gimbal axis unit vector x,y,z 407 AC 6 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,I) 408 AC 6 Inner gimbal- angle(deg), inertia, friction(D,S,B,I) 409 AC 6 Inner gimbal axis unit vector x,y,z 410 AC 6 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 411 AC 6 Initial length and rate, y(to) and ydot(to) 412 AC 6 Constants; K1 or wo, n or zeta, Kg, Jm 413 AC 6 Non-linearities; TLim, Tco, Dz	k) N)
414 AC 7 Actuator ID number 415 AC 7 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 416 AC 7 Actuator location; Node or Hinge (N or H) 417 AC 7 Mounting point body ID number, node ID number 418 AC 7 Second mounting point body ID, second node ID 419 AC 7 Output axis unit vector x,y,z 420 AC 7 Mounting point Hinge index, Axis index 421 AC 7 Rotor spin axis unit vector x,y,z 422 AC 7 Initial rotor momentum, H 423 AC 7 Outer gimbal- angle(deg), inertia, friction(D,S,B, 424 AC 7 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B, 425 AC 7 Inner gimbal- angle(deg), inertia, friction(D,S,B, 426 AC 7 Inner gimbal- angle(deg), inertia, friction(D,S,B, 426 AC 7 Inner gimbal- angle(deg), inertia, friction(D,S,B,	.k)

Bd Systems® TCD20000222A 29 December 2000 7 Inner gimbal axis unit vector x,y,z 7 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 7 Initial length and rate, y(to) and ydot(to)429 AC 7 Constants; K1 or wo, n or zeta, Kg, Jm 430 AC 7 Non-linearities; TLim, Tco, Dz 431 AC Я 8 Actuator ID number 432 AC 8 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 433 AC 8 Actuator location; Node or Hinge (N or H) 8 Mounting point body ID number, node ID number 8 Second mounting point body ID, second node ID 435 AC 436 AC 0 1 0 8 Output axis unit vector x,y,z 437 AC 8 Mounting point Hinge index, Axis index 438 AC 8 Rotor spin axis unit vector x,y,z439 AC 8 Initial rotor momentum, H 8 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 440 AC 441 AC 8 Outer gimbal axis unit vector x,y,z 8 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 442 AC 443 AC 8 Inner gimbal- angle(deg), inertia, friction(D, S, B, N) 444 AC 8 Inner gimbal axis unit vector x,y,z 8 In gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 445 AC 446 AC 8 Initial length and rate, y(to) and ydot(to) 447 AC 8 Constants; K1 or wo, n or zeta, Kg, Jm 448 AC 8 Non-linearities; TLim, Tco, Dz 449 AC 9 Actuator ID number 450 AC 9 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) MO 451 AC 9 Actuator location; Node or Hinge (N or H) 452 AC 9 Mounting point body ID number, node ID number 4 2 9 Second mounting point body ID, second node ID 453 AC 454 AC 0 0 1 9 Output axis unit vector x,y,z 455 AC 9 Mounting point Hinge index, Axis index 456 AC 9 Rotor spin axis unit vector x,y,z 457 AC 9 Initial rotor momentum, H 9 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 458 AC 459 AC 9 Outer gimbal axis unit vector x,y,z 9 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 460 AC 9 Inner gimbal- angle(deg), inertia, friction(D,S,B,N)
9 Inner gimbal axis unit vector x,y,z 461 AC 462 AC 463 AC 9 In gim fric (Tfi, Tgfo, GAM) / (Tfi, M, D, Kf) / (m, M, B, k) 464 AC 9 Initial length and rate, y(to) and ydot(to) 465 AC 9 Constants; K1 or wo, n or zeta, Kg, Jm 466 AC 9 Non-linearities; TLim, Tco, Dz 467 AC 10 468 AC 10 Actuator ID number 469 AC 10 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 470 AC 10 Actuator location; Node or Hinge (N or T. 10 Actuator location; Node or Hinge (N or H) 471 AC 10 Mounting point body ID number, node ID number 2 5 472 AC 10 Second mounting point body ID, second node ID -1 0 0 473 AC 10 Output axis unit vector x,y,z 474 AC 10 Mounting point Hinge index, Axis index 475 AC 10 Rotor spin axis unit vector x,y,z 476 AC 10 Initial rotor momentum, H 477 AC 10 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 478 AC 10 Outer gimbal axis unit vector x,y,z479 AC 10 Out gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k) 10 Inner gimbal- angle(deg), inertia, friction(D,S,B,N) 480 AC 10 Inner gimbal- angle(deg), inertia, it.
481 AC 10 Inner gimbal axis unit vector x, y, z 482 AC 10 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 483 AC 10 Initial length and rate, y(to) and ydot(to) 484 AC 10 Constants; K1 or wo, n or zeta, Kg, Jm 485 AC 10 Non-linearities; TLim, Tco, Dz CONTROLLER 1 Controller ID number 486 CO CM1 Controller type (CB,CM,DB,DM,UC,UD) 487 CO 1 Sample time (sec) 488 CO 9 9 1 Number of inputs, Number of outputs 1 Number of states 489 CO

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491 CO 1 Output No., Input type (I,S,T), Input ID, Gain

INTERCONNECT

492 IN 1 Interconnect ID number 493 IN 1 Source type(S,C, or F), Source ID, Source row # 494 IN 1 Destination type(A or C), Dest ID, Dest row # 495 IN 1 Gain	1 S 1 1 C 1 1 4.41E13
496 IN 2 Interconnect ID number 497 IN 2 Source type(S,C, or F), Source ID, Source row # 498 IN 2 Destination type(A or C), Dest ID, Dest row # 499 IN 2 Gain	2 C 1 1 A 1 1
500 IN 3 Interconnect ID number 501 IN 3 Source type(S,C, or F),Source ID,Source row # 502 IN 3 Destination type(A or C),Dest ID,Dest row # 503 IN 3 Gain	3 S 1 2 C 1 2 1.67E12
504 IN 4 Interconnect ID number 505 IN 4 Source type(S,C, or F),Source ID,Source row # 506 IN 4 Destination type(A or C),Dest ID,Dest row # 507 IN 4 Gain	4 C 1 2 A 2 1
508 IN 5 Interconnect ID number 509 IN 5 Source type(S,C, or F),Source ID,Source row # 510 IN 5 Destination type(A or C),Dest ID,Dest row # 511 IN 5 Gain	5 S 2 1 C 1 3 4.31E13
512 IN 6 Interconnect ID number 513 IN 6 Source type(S,C, or F),Source ID,Source row # 514 IN 6 Destination type(A or C),Dest ID,Dest row # 515 IN 6 Gain	6 C 1 3 A 3 1
516 IN 7 Interconnect ID number 517 IN 7 Source type(S,C, or F),Source ID,Source row # 518 IN 7 Destination type(A or C),Dest ID,Dest row # 519 IN 7 Gain	7 S 3 1 C 1 4 1.7E12
520 IN 8 Interconnect ID number 521 IN 8 Source type(S,C, or F),Source ID,Source row # 522 IN 8 Destination type(A or C),Dest ID,Dest row # 523 IN 8 Gain	8 C 1 4 A 4 1 1
524 IN 9 Interconnect ID number 525 IN 9 Source type(S,C, or F), Source ID, Source row # 526 IN 9 Destination type(A or C), Dest ID, Dest row # 527 IN 9 Gain	9 s 3 2 c 1 5 1.7E12
528 IN 10 Interconnect ID number 529 IN 10 Source type(S,C, or F),Source ID,Source row # 530 IN 10 Destination type(A or C),Dest ID,Dest row # 531 IN 10 Gain	10 C 1 5 A 5 1 1
532 IN 11 Interconnect ID number 533 IN 11 Source type(S,C, or F),Source ID,Source row # 534 IN 11 Destination type(A or C),Dest ID,Dest row # 535 IN 11 Gain	11 S 3 3 C 1 6 3.4E12
536 IN 12 Interconnect ID number 537 IN 12 Source type(S,C, or F),Source ID,Source row # 538 IN 12 Destination type(A or C),Dest ID,Dest row # 539 IN 12 Gain	12 C 1 6 A 6 1 1
540 IN 13 Interconnect ID number 541 IN 13 Source type(S,C, or F),Source ID,Source row # 542 IN 13 Destination type(A or C),Dest ID,Dest row # 543 IN 13 Gain	13 S 4 1 C 1 7 1.7E12
544 IN 14 Interconnect ID number	14

Contract No. NAS8-00151 Bd Systems® TCD20000222A Final Report 29 December 2000 545 IN 14 Source type(S,C, or F), Source ID, Source row # C 1 7 A 7 1 546 IN 14 Destination type(A or C), Dest ID, Dest row # 547 IN 14 Gain 15 548 IN 15 Interconnect ID number 549 IN 15 Source type(S,C, or F), Source ID, Source row # S 4 2 550 IN 15 Destination type(A or C), Dest ID, Dest row # 551 IN 15 Gain C 1 8 1.7E12 16 552 IN 16 Interconnect ID number 553 IN 16 Source type(S,C, or F), Source ID, Source row # C 1 8 554 IN 16 Destination type(A or C), Dest ID, Dest row # A 8 1 555 IN 16 Gain 17 556 IN 17 Interconnect ID number 557 IN 17 Source type(S,C, or F), Source ID, Source row # S 4 3 558 IN 17 Destination type(A or C), Dest ID, Dest row # C 1 9 3.4E12 559 IN 17 Gain 560 IN 18 Interconnect ID number 561 IN 18 Source type(S,C, or F), Source ID, Source row # C 1 9 562 IN 18 Destination type(A or C), Dest ID, Dest row # A 9 1 563 IN 18 Gain 564 IN 19 Interconnect ID number 565 IN 19 Source type(S,C, or F),Source ID,Source row # 19 s 5 3 566 IN 19 Destination type(A or C), Dest ID, Dest row # A 10 1 567 IN 19 Gain

isc3_flex_winsol.int (Concept 3) Winter Solstice

TREETOPS REV 10P2 4/10/00

SIM CONTROL

					THE PROTON
				ISC MODEL,	THIRD VERSION
1		0 Ti		100000	
2	SI	0 Si	mulation stop time	20	
3	SI	0 Pl	ot data interval	R	
4	SI	0 In	tegration type (R,S,U, OR V)	. 1	
5	SI	0 St	ep size (sec)	. –	
6	SI	0 Sa	ndia ODE solver absolute and relative error		
7	SI	0 RK	78 ODE solver absolute error and first step size	N	
8	SI	0 Li	nearization option (L,Z or N)	N	
9	SI	0 Re	estart option (Y/N)	Y	
10	SI	0 Co		N	
	SI		forgo computation oblion (1/N/	A	
	SI		11 1 annodum ontion (All, bypass, 1115c/man)	A	
	SI		anaddun ontion (All, Dybass, 1 12 50)	A	
	SI		annodun ontion (All, bypass, 1 1180)	A	
	SI	0.00	enctraint speedup option (AII, Bypass, FIISC, Itali,	N	
	SI	0 Cc	onstraint stabilization option (1/N)		
	SI	0 St	tabilization epsilon		
_					

GENGRAV

18 GG 19 GG 20 GG 21 GG	<pre>0 Gravity, earth sphere/nonsphere/user (S/N/U)? 1 Input gravity constants: GME, ERAD, EMASS 1 Spherical or Nonspherical (S/N)? 1 Gravity Potential Harmonics J2, J3, J4 0 English (ft-slug-s) or metric (m-kg-s) (E/M)?</pre>	M
22 GG 23 GG 24 GG 25 GG 26 GG	O Day, Month, Year, O GMT @ sim time O (minutes past midnight, O Solar Pressure forces Y/N? O Input new data for aero model? (Y/N)	20 12 2020 360 Y N

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                                                                                  NAS8-00151
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                                                                                   Final Report
29 December 2000
              Solar flux F10 for aero model
  27 GG 1
              Solar flux, 81 day average F10B
  28 GG
        1 Geomagnetic index, GEAP
  29 GG
            BODY
         1 Body ID number
  30 BO
          1 Type (Rigid, Flexible, NASTRAN)
  31 BO
                                                                 24
         1 Number of modes
  32 BO
         1 Modal calculation option (0, 1 or 2)
  33 BO
         1 Foreshortening option (Y/N)
1 Model reduction method (NO,MS,MC,CC,QM,CV)
  34 BO
  35 BO
         1 NASTRAN data file FORTRAN unit number (40 - 60)
  36 BO
         1 Number of augmented nodes (0 if none)
  37 BO
          1 Damping matrix option (NS,CD,HL,SD)
  38 BO
         1 Constant damping ratio
  39 BO
         1 Low frequency, High frequency ratios
  40 BO
         1 Mode ID number, damping ratio
  41 BO
          1 Conversion factors: Length, Mass, Force
  42 BO
  43 BO 1 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
                                                                 6.2852173E11 6.2852173E11
  44 BO 1 Moments of inertia (kg-m2) Ixx, Iyy, Izz
6.7057352E8
          1 Products of inertia (kg-m2) Ixy, Ixz, Iyz
   45 BO
                                                                 1.6168633E5
   46 BO
          1 Mass (kg)
   47 BO 1 Number of Nodes
                                                                 1 0 0 0
          1 Node ID, Node coord. (meters) x,y,z
   48 BO
                                                                 2000
          1 Node ID, Node coord. (meters) x,y,z
                                                                 3 0 0 3188.8
   49 BO
          1 Node ID, Node coord. (meters) x,y,z
1 Node ID, Node coord. (meters) x,y,z
                                                                  4 0 0 -3188.8
   51 BO
           1 Node ID, Node structual joint ID
   52 BO
                                                                  2
           2 Body ID number
   53 BO
                                                                  R
           2 Type (Rigid, Flexible, NASTRAN)
   54 BO
           2 Number of modes
   55 BO
           2 Modal calculation option (0, 1 or 2)
   56 BO
          2 Foreshortening option (Y/N)
   57 BO
           2 Model reduction method (NO,MS,MC,CC,QM,CV)
   58 BO
           2 NASTRAN data file FORTRAN unit number (40 - 60)
   59 BO
          2 Number of augmented nodes (0 if none)
   60 BO
         2 Damping matrix option (NS,CD,HL,SD)
2 Constant damping ratio
   61 BO
   62 BO
   63 BO 2 Low frequency, High frequency ratios
   64 BO 2 Mode ID number, damping ratio
           2 Conversion factors: Length, Mass, Force
   65 BO
   66 BO 2 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1
                                                                  .8543E12 1.5601E12
   67 BO 2 Moments of inertia (kg-m2) Ixx, Iyy, Izz
 1.3822E12
                                                                  0 0 0
   68 BO 2 Products of inertia (kg-m2) Ixy,Ixz,Iyz
                                                                  12666300
    69 BO 2 Mass (kg)
    70 BO 2 Number of Nodes
                                                                  1 298.323 0 0
            2 Node ID, Node coord. (meters) x,y,z
    71 BO
                                                                  2 0 0 0
           2 Node ID, Node coord. (meters) x,y,z
                                                                  3 0 0 300
    72 BO
           2 Node ID, Node coord. (meters) x,y,z
    73 BO
                                                                   4 0 0 -300
           2 Node ID, Node coord. (meters) x,y,z
    74 BO
                                                                   5 500 0 0
           2 Node ID, Node coord. (meters) x,y,z
    75 BO
           2 Node ID, Node structual joint ID
    76 BO
                                                                   3
            3 Body ID number
    77 BO
           3 Type (Rigid, Flexible, NASTRAN)
    78 BO
           3 Number of modes
           3 Modal calculation option (0, 1 or 2) 3 Foreshortening option (Y/N)
    80 BO
    81 BO
           3 Model reduction method (NO,MS,MC,CC,QM,CV)
    82 BO
           3 NASTRAN data file FORTRAN unit number (40 - 60)
    83 BO
            3 Number of augmented nodes (0 if none)
    84 BO
           3 Damping matrix option (NS,CD,HL,SD)
    85 BO
           3 Constant damping ratio
           3 Low frequency, High frequency ratios
3 Mode ID number, damping ratio
    87 BO
    88 BO
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Bd Systems® NAS8-00151 TCD20000222A Final Report 29 December 2000 89 BO 3 Conversion factors: Length, Mass, Force 90 BO 3 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 91 BO 3 Moments of inertia (kg-m2) Ixx,Iyy,Izz 1.7E12 1.7E12 3.4E12 92 BO 3 Products of inertia (kg-m2) Ixy,Ixz,Iyz 0 0 0 93 BO 3 Mass (kg) 94 BO 3 Number of Nodes 95 BO 3 Node ID, Node coord. (meters) x,y,z 96 BO 3 Node ID, Node coord. (meters) x,y,z 1 0 0 0 2 0 0 0 97 BO 3 Node ID, Node structual joint ID 98 BO 4 Body ID number R 99 BO 4 Type (Rigid, Flexible, NASTRAN) 100 BO 4 Number of modes 101 BO 4 Modal calculation option (0, 1 or 2) 102 BO 4 Foreshortening option (Y/N) 103 BO 4 Model reduction method (NO,MS,MC,CC,QM,CV) 104 BO 4 NASTRAN data file FORTRAN unit number (40 - 60) 105 BO 4 Number of augmented nodes (0 if none) 106 BO 4 Damping matrix option (NS,CD,HL,SD) 107 BO 4 Constant damping ratio 108 BO 4 Low frequency, High frequency ratios 109 BO 4 Mode ID number, damping ratio 110 BO 4 Conversion factors: Length, Mass, Force 111 BO 4 Inertia reference node (0=Bdy Ref Frm; 1=mass cen) 1 112 BO 4 Moments of inertia (kg-m2) Ixx, Iyy, Izz 1.7E12 1.7E12 3.4E12 13 BO 4 Products of inertia (kg-m2) Ixy, Ixz, Iyz 0 0 0 114 BO 4 Mass (kg) 115 BO 4 Number of Nodes 116 BO 4 Node ID, Node coord. (meters) x,y,z 117 BO 4 Node ID, Node coord. (meters) x,y,z 1 0 0 0 2000 118 BO 4 Node ID, Node structual joint ID HINGE 119 HI 1 Hinge ID number 120 HI 1 Inboard body ID, 1 Inboard body ID, Outboard body ID 121 HI 1 "p" node ID, "q" node ID 122 HI 1 Number of rotation DOFs, Rotation option (F or G)
123 HI 1 L1 unit vector in inboard body coord. x,y,z
124 HI 1 L1 unit vector in outboard body coord. x,y,z 125 HI 1 L2 unit vector in inboard body coord. x,y,z 131 HI 1 Rotation stiffness (newton-meters/rad/sec) 0 0 0 0 132 HI 1 Rotation damping (newton-meters/rad/sec) 0 0 0 133 HI 1 Null torque angles (deg) 134 HI 1 Number of translation DOFs 1 0 0 134 HI 1 Number of translation DOFS
135 HI 1 First translation unit vector g1
136 HI 1 Second translation unit vector g2
137 HI 1 Third translation unit vector g3 0 1 0 0 0 1 0 0 42163421 138 HI 1 Initial translation (meters) 138 HI 1 Initial translation (meters)

139 HI 1 Initial translation velocity (meters/sec)

139 HI 1 Initial translation stiffness (newtons/meters)

1 Translation stiffness (newtons/meters) 3074.681 0 0 140 HI 1 Translation stiffness (newtons/meters)
141 HI 1 Translation damping (newtons/meter/sec) 0 0 0 0 0 0 142 HI 1 Null force translations 2 Hinge ID number 143 HI 1 2 144 HI 2 Inboard body ID, Outboard body ID 145 HI 2 "p" node ID, "q" node ID 146 HI 2 Number of rotation DOFs 147 HI 2 L1 unit vector in inboard body coord. x,y,z 0 0 1 147 HI 2 L1 unit vector in outboard body coord. x,y,z
148 HI 2 L2 unit vector in inboard body coord. x,y,z
149 HI 2 L2 unit vector in inboard body coord. x,y,z
150 HI 2 L2 unit vector in outboard body coord. x,y,z 0 0 1 1 0 0 152 HI 2 L3 unit vector in inboard body coord. x,y,z 152 HI 2 L3 unit vector in outboard body coord. x,y,z 153 HI 2 Initial rotation angles (deg) 151 HI 2 L3 unit vector in inboard body coord. x,y,z 1 0 0 0 0 0

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Contract No. NAS8-00151 Bd Systems® TCD20000222A Final Report 29 December 2000 2 Initial rotation rates (deg/sec) 154 HI 2 Rotation stiffness (newton-meters/rad) 156 HI 2 Rotation damping (newton-meters/rad/sec) 157 HI 2 Null torque angles (deg) 0 158 HI 2 Number of translation DOFs 1 0 0 150 HI 2 First translation unit vector g1 160 HI 2 Second translation unit vector g2 161 HI 2 Third translation unit vector g3 0 1 0 0 0 1 0 0 0 162 HI 2 Initial translation (meters) 163 HI 2 Initial translation velocity (meters/sec) 2 Translation stiffness (newtons/meters) 164 HI 165 HI 2 Translation damping (newtons/meter/sec) 166 HI 2 Null force translations 167 HI 3 Hinge ID number 168 HI 3 Inboard body ID, Outboard body ID 169 HI 3 "p" node ID, "q" node ID 3 2 170 HI 3 Number of rotation DOFs 171 HI 3 L1 unit vector in inboard body coord. x,y,z 0 0 1 172 HI 3 L1 unit vector in outboard body coord. x,y,z 0 0 1 172 HI 3 L1 unit vector in inboard body coord. x,y,z
173 HI 3 L2 unit vector in inboard body coord. x,y,z
174 HI 3 L2 unit vector in outboard body coord. x,y,z
175 HI 3 L3 unit vector in inboard body coord. x,y,z 0 1 0 176 HI 3 L3 unit vector in outboard body coord. x,y,z 0 1 0 -90. 0. -146.75 177 HI 3 Initial rotation angles (deg) 178 HI 3 Initial rotation rates (deg/sec) -0.004178 0 0 179 HI 3 Rotation stiffness (newton-meters/rad) 0 0 0 180 HI 3 Rotation damping (newton-meters/rad/sec) 0 0 0 0 0 0 181 HI 3 Null torque angles (deg) 182 HI 3 Number of translation DOFs 1 0 0 183 HI 3 First translation unit vector g1 0 1 0 184 HI 3 Second translation unit vector g2 185 HI 3 Third translation unit vector g3 0 0 1 0 0 0 186 HI 3 Initial translation (meters) 187 HI 3 Initial translation velocity (meters/sec) 188 HI 3 Translation stiffness (newtons/meters) 189 HI 3 Translation damping (newtons/meter/sec) 190 HI 3 Null force translations 4 Hinge ID number 191 HI 4 Inboard body ID, Outboard body ID 4 "p" node ID, "q" node ID 1 4 192 HI 4 2 4 Number of rotation DOFs 4 L1 unit vector in inboard body coord. x,y,z 193 HI 0 0 1 194 HI 196 HI 4 L1 unit vector in outboard body coord. x,y,z 195 HI 0 0 1 197 HI 4 L2 unit vector in inboard body coord. x,y,z 4 L2 unit vector in outboard body coord. x,y,z 199 HI 4 L3 unit vector in inboard body coord. x,y,z 198 HI 0 1 0 200 HI 4 L3 unit vector in outboard body coord. x,y,z 0 1 0 -90. 0. -56.75 201 HI 4 Initial rotation angles (deg) 202 HI 4 Initial rotation rates (deg/sec) -0.004178 0 0 203 HI 4 Rotation stiffness (newton-meters/rad) 0 0 0 204 HI 4 Rotation damping (newton-meters/rad/sec) 0 0 0 0 0 0 4 Null torque angles (deg) 205 HI 4 Null torque angles (deg) 206 HI 4 Number of translation DOFs 0 1 0 0 207 HI 4 First translation unit vector g1 0 1 0 208 HI 4 Second translation unit vector g2 209 HI 4 Third translation unit vector g3 0 0 1 0 0 0 210 HI 4 Initial translation (meters) 211 HI 4 Initial translation velocity (meters/sec) 4 Translation stiffness (newtons/meters)
4 Translation damping (newtons/meter/sec) 212 HI 213 HI 214 HI 4 Null force translations SENSOR 1 Sensor ID number 1 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ET 215 SE 217 SE 1 Mounting point body ID, Mounting point node ID 1 Second mounting point body ID, Second node ID 218 SE

NAS8-00151 Bd Systems® TCD20000222A Final Report 29 December 2000 219 SE 1 Input axis unit vector (IA) x,y,z 1 Mounting point Hinge index, Axis index 1 First focal plane unit vector (Fp1) x,y,z 1 Second focal plane unit vector (Fp2) x,y,z 0 0 -1 0 1 0 222 SE 1 Sun/Star unit vector (Us) x,y,z 223 SE 1 Velocity Aberration Option (Y/N) 1 Euler Angle Sequence (1-6) 224 SE 225 SE 1 CMG ID number and Gimbal number 6378000 0 0 4.178074D-3 226 SE 1 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 227 SE 2 Sensor ID number 229 SE 2 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST 2 Mounting point body ID, Mounting point node ID 2 Second mounting point body ID, Second node ID 230 SE 231 SE 2 Input axis unit vector (IA) x,y,z 232 SE 233 SE 2 Mounting point Hinge index, Axis index 0 -1 0 2 First focal plane unit vector (Fp1) x,y,z 234 SE 2 Second focal plane unit vector (Fp2) x,y,z 1 0 0 235 SE 0 1 0 2 Sun/Star unit vector (Us) x,y,z 236 SE 237 SE 2 Velocity Aberration Option (Y/N) 2 Euler Angle Sequence (1-6) 238 SE 239 SE 2 CMG ID number and Gimbal number 240 SE 2 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 3 Sensor ID number 3 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) L 241 SE 242 SE 3 Mounting point body ID, Mounting point node ID 243 SE 3 Second mounting point body ID, Second node ID 3 Input axis unit vector (IA) x,y,z 244 SE 1 2 3 245 SE 3 Mounting point Hinge index, Axis index 246 SE 247 SE 3 First focal plane unit vector (Fp1) x,y,z 3 Second focal plane unit vector (Fp2) x,y,z248 SE 249 SE 3 Sun/Star unit vector (Us) x,y,z 250 SE 3 Velocity Aberration Option (Y/N) 3 Euler Angle Sequence (1-6) 251 SE 252 SE 3 CMG ID number and Gimbal number 253 SE 3 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 4 Sensor ID number 255 SE 4 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) L 256 SE 4 Mounting point body ID, Mounting point node ID 257 SE 4 Second mounting point body ID, Second node ID 258 SE 4 Input axis unit vector (IA) x,y,z 3 2 1 259 SE 4 Mounting point Hinge index, Axis index 260 SE 4 First focal plane unit vector (Fp1) x,y,z 4 Second focal plane unit vector (Fp2) x,y,z 261 SE 262 SE 4 Sun/Star unit vector (Us) x,y,z 263 SE 4 Velocity Aberration Option (Y/N) 264 SE 4 Euler Angle Sequence (1-6) 4 CMG ID number and Gimbal number 265 SE 266 SE 4 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 5 Sensor ID number 267 SE 5 Type (G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET) ST 5 Mounting point body ID, Mounting point node ID 268 SE 269 SE 5 Second mounting point body ID, Second node ID 5 Input axis unit vector (IA) x,y,z 270 SE 5 Mounting point Hinge index, Axis index 272 SE 5 First focal plane unit vector (Fp1) x,y,z 273 SE 0 -1 0 5 Second focal plane unit vector (Fp2) x,y,z 274 SE 0 0 0 5 Sun/Star unit vector (Us) x,y,z 275 SE 5 Velocity Aberration Option (Y/N) 276 SE 5 Euler Angle Sequence (1-6) 5 CMG ID number and Gimbal number 277 SE 278 SE 279 SE 5 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 6 Sensor ID number 280 SE 6 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV A3 281 SE 6 Mounting point body ID, Mounting point node ID 283 SE 6 Second mounting point body ID, Second node ID 284 SE 6 Input axis unit vector (IA) x,y,z

Contract No.

Contract No. Bd Systems® NAS8-00151 TCD20000222A Final Report 29 December 2000 6 Mounting point Hinge index, Axis index 6 First focal plane unit vector (Fp1) x,y,z 6 Second focal plane unit vector (Fp2) x,y,z 6 Sun/Star unit vector (Us) x,y,z 288 SE 6 Velocity Aberration Option (Y/N) 6 Euler Angle Sequence (1-6) 290 SE 6 CMG ID number and Gimbal number 291 SE 6 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 292 SE 7 Sensor ID number 293 SE 7 Typ(G,R,AN,V,P,AC,T,I,SU,ST,L,IM,P3,V3,CR,CT,ET,LV AC 294 SE 7 Mounting point body ID, Mounting point node ID 295 SE 7 Second mounting point body ID, Second node ID 296 SE 1 0 0 7 Input axis unit vector (IA) x,y,z 297 SE 7 Mounting point Hinge index, Axis index 298 SE 7 First focal plane unit vector (Fp1) x,y,z 299 SE 7 Second focal plane unit vector (Fp2) x,y,z 300 SE 7 Sun/Star unit vector (Us) x,y,z 301 SE 7 Velocity Aberration Option (Y/N) 302 SE 7 Euler Angle Sequence (1-6) 303 SE 7 CMG ID number and Gimbal number 304 SE 7 Earth pt (rad, lat, lon, rotation [m/e, d, d, d/s]) 305 SE ACTR 1 Actuator ID number 306 AC MO 1 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 307 AC 1 Actuator location; Node or Hinge (N or H) 308 AC 1 Mounting point body ID number, node ID number 2 2 309 AC 1 Second mounting point body ID, second node ID 310 AC 0 1 0 1 Output axis unit vector x,y,z 311 AC

1 Mounting point Hinge index, Axis index 312 AC 1 Rotor spin axis unit vector x,y,z 313 AC 1 Initial rotor momentum, H 314 AC 1 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 315 AC 1 Outer gimbal axis unit vector x,y,z 316 AC 1 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k)
1 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 317 AC 318 AC 1 Inner gimbal axis unit vector x,y,z 319 AC 1 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 320 AC 1 Initial length and rate, y(to) and ydot(to) 321 AC 1 Constants; K1 or wo, n or zeta, Kg, Jm 322 AC 1 Non-linearities; TLim, Tco, Dz 323 AC 2 2 Actuator ID number 324 AC MO 2 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 325 AC 2 Actuator location; Node or Hinge (N or H) 326 AC 2 Mounting point body ID number, node ID number 2 2 327 AC 2 Second mounting point body ID, second node ID 328 AC 0 0 1 2 Output axis unit vector x,y,z 329 AC 2 Mounting point Hinge index, Axis index 2 Rotor spin axis unit vector x,y,z331 AC 2 Initial rotor momentum, H 332 AC 2 Outer gimbal- angle(deg), inertia, friction(D,S,B,N) 333 AC 2 Outer gimbal axis unit vector x,y,z 334 AC 2 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 335 AC 2 Inner gimbal- angle(deg),inertia,friction(D,S,B,N) 336 AC 2 Inner gimbal axis unit vector x,y,z 337 AC 2 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,k) 338 AC 2 Initial length and rate, y(to) and ydot(to) 339 AC 2 Constants; K1 or wo, n or zeta, Kg, Jm 340 AC 2 Non-linearities; TLim, Tco, Dz 341 AC 3 Actuator ID number 342 AC MO 3 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7) 343 AC 3 Actuator location; Node or Hinge (N or H) 344 AC 3 Mounting point body ID number, node ID number 2 2 345 AC 3 Second mounting point body ID, second node ID 346 AC 3 Output axis unit vector x,y,z 1 0 0 347 AC 3 Mounting point Hinge index, Axis index

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352 353		α out wim frid (Φ fi Ψ afo, GAM)/(Ψ f1, M, D, K1)/(Π , Π , D, K)	
354		3 Inner gimbal- angle(deg), inertia, iliction(b, 5, b, K)	
355		2 Throw gimbal axis unit vector X, Y, Z	
356		3 In gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k) 3 In gim fric (Tfi, Tgfo, GAM)/(Tfi, M, D, Kf)/(m, M, B, k)	
357		3 Initial length and rate, y(to) and ydot(to) 3 Initial length and rate, y(to) and ydot(to)	
358		3 Constants; K1 or wo, n or zeta, Kg, Jm 3 Non-linearities; TLim, Tco, Dz	
359	AC	3 Non-Timedicies, Talin, 111,	
360	AC	4 Actuator ID number	4 MO
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362		A Actuator location: Node or Hinge (N OI II)	3 2
363		4 Mounting point body ID number, node ID number 4 Second mounting point body ID, second node ID	
364		4 Output axis unit vector x,y,z	1 0 0
365 366		4 Mounting point Hinge index, Axis index	
367		4 Rotor spin axis unit vector x, y, z	
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369		4 Unter gimbal - angle (deg), inertia, friction (D, S, B, N)	
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371 372		4 Out gim file (fil, 1910, star,) 4 Inner gimbal- angle(deg), inertia, friction(D, S, B, N)	
373		4 Impor gimbal axis unit Vector X, Y, Z	
374		A In gim fric (Tfi. Tgfo, GAM)/(Til, M, D, Ki//(M, M, D, K)	
375	AC	A Initial length and rate, y(to) and ydot(to)	
376		4 Constants; K1 or wo, n or zeta, Kg, Jm	
377	AC	4 Non-linearities; TLim, Tco, Dz	
378	ΔC	5 Actuator ID number	5
379		5 mme(J H MO T.B.MA, SG, DG, W, L, MI-M/)	MO
	AC	s Agruator location: Node or Hinge (N OI n)	3 2
381	AC	5 Mounting point body ID number, node ID number	J 2
	AC	5 Second mounting point body ID, second node ID 5 Output axis unit vector x,y,z	0 1 0
	AC	5 Mounting point Hinge index, Axis index	
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	AC.	5 Initial length and rate, Y(to) and Ydot(to)	
394	1 AC	5 Constants; K1 or wo, n or zeta, Kg, Jm	
395	AC	5 Non-linearities; TLim, Tco, Dz	
206	5 AC	6 Actuator ID number	6 W2
	7 AC	Commett H MO T. B. MA. SG, DG, W, L, MI-M/)	MO
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40!	5 AC	6 Outer gimbal - angle(deg), inertia, friction(D, S, B, N)	
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	7 AC	6 Inner gimbal- angle(deg), inertia, iliction(b, b, b, k,)
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41	3 AC	0 MOH-IIHealicies, Ibim, 100, 1-	_
41	4 AC	7 Actuator ID number	7 MO
	5 AC	7 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7)	MO

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418 AC	7 Output axis unit vector X, Y, Z	1 0 0
419 AC	7 Mounting point Hinge index, Axis index	
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421 AC 422 AC	1.1.1 1t momoratum H	
423 AC	7 Outer gimbal - angle (deg), inertia, friction(b, b, b, m)	
424 AC	n a wimbal avid unit Vector A, V, 4	
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426 AC	7 Out gim fric (fff, iglo, dim, retia, friction (D, S, B, N) 7 Inner gimbal - angle (dep, inertia, friction (D, S, B, N)	
427 AC	a = = e = b = l avid init Vector A/Y/4	
428 AC	7 Inner gimbal axis unit of the first state of the	
429 AC	7 Initial length and late, yets, and 7 Constants; K1 or wo, n or zeta, Kg, Jm	
430 AC	7 Constants; KI of wo, h of Lett, 7 Non-linearities; TLim, Tco, Dz	
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422 70	8 Actuator ID number	8
432 AC	O THE OF THE MO THE MA. SG. DG. W. L. MITM!	MO
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436 AC	8 Second mounting point body ID, second hode ID	0 1 0
437 AC	e Output axis unit vector X,Y,Z	0 2 0
438 AC	9 Mounting point Hinge Index, AXIS Index	
439 AC	8 Rotor spin axis unit vector x,y,z	
440 AC	8 Initial rotor momentum, H 8 Outer gimbal- angle(deg), inertia, friction(D,S,B,N)	
441 AC	8 Outer gimbal axis unit vector x,y,z 8 Outer gimbal axis unit vector x,y,z	
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443 AC	8 Out gim file (fil, iglo, din) inertia, friction(D,S,B,N) 8 Inner gimbal- angle(deg), inertia, friction(D,S,B,N)	
444 AC	a = mimbal avic unit Vector X, Y, 4	
445 AC 446 AC	α r_{-} α in fric (Tfi Tqfo.GAM)/(TII,M,D,KI)/(M,M,D,K)	
447 AC	o Initial length and rate, Y(to) and ydoctor	
448 AC	8 Constants: K1 or wo, n or zeta, kg, om	
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450 AC 451 AC 452 AC 453 AC 455 AC 456 AC 457 AC 458 AC 459 AC 461 AC 461 AC 462 AC 463 AC 464 AC 465 AC 466 AC 467 AC	9 Actuator ID number 9 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 9 Actuator location; Node or Hinge (N or H) 9 Mounting point body ID number, node ID number 9 Second mounting point body ID, second node ID 9 Output axis unit vector x,y,z 9 Mounting point Hinge index, Axis index 9 Rotor spin axis unit vector x,y,z 9 Initial rotor momentum, H 9 Outer gimbal- angle(deg), inertia, friction(D,S,B,N); 9 Outer gimbal axis unit vector x,y,z 9 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K); 9 Inner gimbal- angle(deg), inertia, friction(D,S,B,N); 1 Inner gimbal axis unit vector x,y,z 9 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K); 1 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K); 9 Initial length and rate, y(to) and ydot(to); 9 Constants; K1 or wo, n or zeta, Kg, Jm; 9 Non-linearities; TLim, Tco, Dz 10 Actuator ID number 10 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US); 11 Actuator location; Node or Hinge (N or H); 12 Second mounting point body ID number, node ID number	MO 4 2 0 0 1
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450 AC 451 AC 452 AC 453 AC 454 AC 455 AC 456 AC 457 AC 458 AC 461 AC 461 AC 462 AC 463 AC 464 AC 465 AC 466 AC 467 AC 468 AC 467 AC 471 AC 472 AC 473 AC 474 AC 475 AC	9 Actuator ID number 9 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 9 Actuator location; Node or Hinge (N or H) 9 Mounting point body ID number, node ID number 9 Second mounting point body ID, second node ID 9 Output axis unit vector x,y,z 9 Mounting point Hinge index, Axis index 9 Rotor spin axis unit vector x,y,z 9 Initial rotor momentum, H 9 Outer gimbal- angle(deg), inertia, friction(D,S,B,N); 9 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K); 9 Inner gimbal axis unit vector x,y,z 9 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K); 9 Inner gimbal axis unit vector x,y,z 9 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K); 9 Initial length and rate, y(to) and ydot(to); 9 Constants; K1 or wo, n or zeta, Kg, Jm; 9 Non-linearities; TLim, Tco, Dz 10 Actuator ID number 10 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US); 10 Actuator location; Node or Hinge (N or H); 10 Mounting point body ID number, node ID number; 10 Second mounting point body ID, second node ID; 10 Output axis unit vector x,y,z 10 Mounting point Hinge index, Axis index; 10 Rotor spin axis unit vector x,y,z 10 Initial rotor momentum, H	MO 4 2 0 0 1 10 J 2 5 -1 0 0
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450 AC 451 AC 452 AC 453 AC 454 AC 455 AC 456 AC 457 AC 458 AC 461 AC 462 AC 463 AC 464 AC 465 AC 466 AC 467 AC 468 AC 467 AC 468 AC 467 AC 471 AC 472 AC 473 AC 474 AC 475 AC 476 AC 477 AC 477 AC 477 AC	9 Actuator ID number 9 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 9 Actuator location; Node or Hinge (N or H) 9 Mounting point body ID number, node ID number 9 Second mounting point body ID, second node ID 9 Output axis unit vector x,y,z 9 Mounting point Hinge index, Axis index 9 Rotor spin axis unit vector x,y,z 9 Initial rotor momentum, H 9 Outer gimbal- angle(deg),inertia,friction(D,S,B,N); 9 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 9 Inner gimbal- angle(deg),inertia,friction(D,S,B,N); 1 Inner gimbal axis unit vector x,y,z 9 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K); 1 Initial length and rate, y(to) and ydot(to) 9 Constants; K1 or wo, n or zeta, Kg, Jm 9 Non-linearities; TLim, Tco, Dz 10 Actuator ID number 10 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 10 Actuator location; Node or Hinge (N or H) 10 Mounting point body ID number, node ID number 10 Second mounting point body ID, second node ID 10 Output axis unit vector x,y,z 11 Mounting point Hinge index, Axis index 12 Rotor spin axis unit vector x,y,z 13 Initial rotor momentum, H 14 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 15 Ario (MS, MG, MG, MG, MM, M, M	MO 4 2 0 0 1 10 J 2 5 -1 0 0
450 AC 451 AC 452 AC 453 AC 455 AC 456 AC 457 AC 458 AC 459 AC 461 AC 462 AC 463 AC 464 AC 465 AC 467 AC 468 AC 467 AC 471 AC 472 AC 473 AC 474 AC 475 AC 476 AC 477 AC 478 AC 478 AC	9 Actuator ID number 9 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 9 Actuator location; Node or Hinge (N or H) 9 Mounting point body ID number, node ID number 9 Second mounting point body ID, second node ID 9 Output axis unit vector x,y,z 9 Mounting point Hinge index, Axis index 9 Rotor spin axis unit vector x,y,z 9 Initial rotor momentum, H 9 Outer gimbal- angle(deg),inertia,friction(D,S,B,N; 9 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 9 Inner gimbal- angle(deg),inertia,friction(D,S,B,N; 9 Inner gimbal axis unit vector x,y,z 9 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 9 Initial length and rate, y(to) and ydot(to) 9 Constants; K1 or wo, n or zeta, Kg, Jm 9 Non-linearities; TLim, Tco, Dz 10 Actuator ID number 10 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 10 Actuator location; Node or Hinge (N or H) 10 Mounting point body ID number, node ID number 10 Second mounting point body ID, second node ID 10 Output axis unit vector x,y,z 10 Mounting point Hinge index, Axis index 10 Rotor spin axis unit vector x,y,z 10 Initial rotor momentum, H 10 Outer gimbal- angle(deg), inertia, friction(D,S,B,N) 10 Inner gimbal- angle(deg), inertia, friction(D,S,B,N)	MO 4 2 0 0 1 10 J 2 5 -1 0 0
450 AC 451 AC 452 AC 453 AC 454 AC 455 AC 456 AC 457 AC 458 AC 461 AC 462 AC 463 AC 464 AC 465 AC 466 AC 467 AC 468 AC 467 AC 468 AC 467 AC 471 AC 472 AC 473 AC 474 AC 475 AC 476 AC 477 AC 477 AC 477 AC	9 Actuator ID number 9 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 9 Actuator location; Node or Hinge (N or H) 9 Mounting point body ID number, node ID number 9 Second mounting point body ID, second node ID 9 Output axis unit vector x,y,z 9 Mounting point Hinge index, Axis index 9 Rotor spin axis unit vector x,y,z 9 Initial rotor momentum, H 9 Outer gimbal- angle(deg),inertia,friction(D,S,B,N) 9 Outer gimbal axis unit vector x,y,z 9 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 9 Inner gimbal axis unit vector x,y,z 9 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 9 Initial length and rate, y(to) and ydot(to) 9 Constants; K1 or wo, n or zeta, Kg, Jm 9 Non-linearities; TLim, Tco, Dz 10 Actuator ID number 10 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 11 Actuator location; Node or Hinge (N or H) 12 Mounting point body ID number, node ID number 13 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 14 Output axis unit vector x,y,z 15 Mounting point hinge index, Axis index 16 Rotor spin axis unit vector x,y,z 17 Initial rotor momentum, H 18 Outer gimbal- angle(deg),inertia,friction(D,S,B,M) 19 Outer gimbal axis unit vector x,y,z 10 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,M) 10 Inner gimbal- angle(deg),inertia,friction(D,S,B,M) 11 Inner gimbal- axis unit vector x,y,z 12 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,M) 13 Inner gimbal- axis unit vector x,y,z 14 Outer gimbal- axis unit vector x,y,z	MO 4 2 0 0 1 10 J 2 5 -1 0 0
450 AC 451 AC 452 AC 453 AC 454 AC 455 AC 456 AC 457 AC 460 AC 461 AC 462 AC 463 AC 464 AC 465 AC 466 AC 467 AC 468 AC 470 AC 471 AC 472 AC 473 AC 474 AC 475 AC 476 AC 477 AC 478 AC 478 AC 479 AC	9 Actuator ID number 9 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 9 Actuator location; Node or Hinge (N or H) 9 Mounting point body ID number, node ID number 9 Second mounting point body ID, second node ID 9 Output axis unit vector x,y,z 9 Mounting point Hinge index, Axis index 9 Rotor spin axis unit vector x,y,z 9 Initial rotor momentum, H 9 Outer gimbal axis unit vector x,y,z 9 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 9 Inner gimbal angle(deg),inertia,friction(D,S,B,N) 9 Inner gimbal axis unit vector x,y,z 9 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 9 Inner gimbal axis unit vector x,y,z 9 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 9 Initial length and rate, y(to) and ydot(to) 9 Constants; K1 or wo, n or zeta, Kg, Jm 9 Non-linearities; TLim, Tco, Dz 10 Actuator ID number 10 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 10 Actuator location; Node or Hinge (N or H) 10 Mounting point body ID number, node ID number 10 Second mounting point body ID, second node ID 10 Output axis unit vector x,y,z 10 Mounting point Hinge index, Axis index 10 Rotor spin axis unit vector x,y,z 11 Initial rotor momentum, H 12 Outer gimbal axis unit vector x,y,z 13 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 14 Outer gimbal axis unit vector x,y,z 15 Inner gimbal axis unit vector x,y,z 16 Inner gimbal axis unit vector x,y,z 17 Inner gimbal axis unit vector x,y,z 18 Inner gimbal axis unit vector x,y,z 19 Inner gimbal axis unit vector x,y,z 10 Inner gimbal axis unit vector x,y,z 11 Inner gimbal axis unit vector x,y,z 12 Inner gimbal axis unit vector x,y,z 13 Inner gimbal axis unit vector x,y,z 14 Inner gimbal axis unit vector x,y,z	MO 4 2 0 0 1 10 J 2 5 -1 0 0
450 AC 451 AC 452 AC 453 AC 454 AC 455 AC 456 AC 457 AC 458 AC 461 AC 463 AC 464 AC 465 AC 466 AC 467 AC 468 AC 467 AC 468 AC 470 AC 471 AC 472 AC 473 AC 474 AC 475 AC 477 AC 478 AC 478 AC 479 AC 480 AC	9 Actuator ID number 9 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 9 Actuator location; Node or Hinge (N or H) 9 Mounting point body ID number, node ID number 9 Second mounting point body ID, second node ID 9 Output axis unit vector x,y,z 9 Mounting point Hinge index, Axis index 9 Rotor spin axis unit vector x,y,z 9 Initial rotor momentum, H 9 Outer gimbal- angle(deg),inertia,friction(D,S,B,N); 9 Outer gimbal axis unit vector x,y,z 9 Out gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 9 Inner gimbal axis unit vector x,y,z 9 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 9 Initial length and rate, y(to) and ydot(to) 9 Constants; K1 or wo, n or zeta, Kg, Jm 9 Non-linearities; TLim, Tco, Dz 10 Actuator ID number 10 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 10 Actuator location; Node or Hinge (N or H) 10 Mounting point body ID number, node ID number 10 Type(J,H,MO,T,B,MA,SG,DG,W,L,M1-M7,US) 10 Actuator location; Node or Hinge (N or H) 10 Mounting point body ID, second node ID 10 Output axis unit vector x,y,z 10 Mounting point Hinge index, Axis index 10 Rotor spin axis unit vector x,y,z 10 Initial rotor momentum, H 10 Outer gimbal- angle(deg), inertia, friction(D,S,B,M) 10 Outer gimbal- angle(deg), inertia, friction(D,S,B,M) 10 Inner gimbal- angle(deg), inertia, friction(D,S,B,M) 10 Inner gimbal axis unit vector x,y,z 10 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K) 10 Inner gimbal axis unit vector x,y,z 10 In gim fric (Tfi,Tgfo,GAM)/(Tfi,M,D,Kf)/(m,M,B,K)	MO 4 2 0 0 1 10 J 2 5 -1 0 0

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29 December 2000

484 AC 10 Constants; K1 or wo, n or zeta, Kg, Jm 485 AC 10 Non-linearities; TLim, Tco, Dz

CONTROLLER

486 CO 487 CO	1 Controller ID number 1 Controller type (CB,CM,DB,DM,UC,UD)	1 CM
488 CO 489 CO	1 Sample time (sec) 1 Number of inputs, Number of outputs 1 Number of states	9 9
490 CO 491 CO	1 Output No., Input type (I,S,T), Input ID, Gain	
	INTERCONNECT	
492 IN 493 IN 494 IN 495 IN	<pre>1 Interconnect ID number 1 Source type(S,C, or F),Source ID,Source row # 1 Destination type(A or C),Dest ID,Dest row # 1 Gain</pre>	1 S 1 1 C 1 1 4.41E13
496 IN 497 IN 498 IN 499 IN	<pre>2 Interconnect ID number 2 Source type(S,C, or F),Source ID,Source row # 2 Destination type(A or C),Dest ID,Dest row # 2 Gain</pre>	2 C 1 1 A 1 1
500 IN 501 IN 502 IN 503 IN	<pre>3 Interconnect ID number 3 Source type(S,C, or F),Source ID,Source row # 3 Destination type(A or C),Dest ID,Dest row # 3 Gain</pre>	3 S 1 2 C 1 2 1.67E12
504 IN 505 IN 506 IN 507 IN	<pre>4 Interconnect ID number 4 Source type(S,C, or F),Source ID,Source row # 4 Destination type(A or C),Dest ID,Dest row # 4 Gain</pre>	4 C 1 2 A 2 1
508 IN 509 IN 510 IN 511 IN	<pre>5 Interconnect ID number 5 Source type(S,C, or F),Source ID,Source row # 5 Destination type(A or C),Dest ID,Dest row # 5 Gain</pre>	5 S 2 1 C 1 3 4.31E13
512 IN 513 IN 514 IN 515 IN	<pre>6 Interconnect ID number 6 Source type(S,C, or F),Source ID,Source row # 6 Destination type(A or C),Dest ID,Dest row # 6 Gain</pre>	6 C 1 3 A 3 1
516 IN 517 IN 518 IN 519 IN	<pre>7 Interconnect ID number 7 Source type(S,C, or F),Source ID,Source row # 7 Destination type(A or C),Dest ID,Dest row # 7 Gain</pre>	7 S 3 1 C 1 4 1.7E12
520 IN 521 IN 522 IN 523 IN	<pre>8 Interconnect ID number 8 Source type(S,C, or F),Source ID,Source row # 8 Destination type(A or C),Dest ID,Dest row # 8 Gain</pre>	8 C 1 4 A 4 1 1
524 IN 525 IN 526 IN 527 IN	9 Interconnect ID number 9 Source type(S,C, or F),Source ID,Source row # 9 Destination type(A or C),Dest ID,Dest row # 9 Gain	9 S 3 2 C 1 5 1.7E12
528 IN 529 IN 530 IN 531 IN	10 Interconnect ID number 10 Source type(S,C, or F),Source ID,Source row # 10 Destination type(A or C),Dest ID,Dest row # 10 Gain	10 C 1 5 A 5 1 1
532 IN 533 IN 534 IN 535 IN	11 Interconnect ID number 11 Source type(S,C, or F),Source ID,Source row # 11 Destination type(A or C),Dest ID,Dest row # 11 Gain	11 S 3 3 C 1 6 3.4E12

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Bd Systems® TCD20000222A 29 December 2000 536 IN 12 Interconnect ID number 537 IN 12 Source type(S.C. or F).Source ID.Source row # 538 IN 12 Destination type(A or C).Dest ID.Dest row # C 1 6 A 6 1 1 539 IN 12 Gain 13 540 IN 13 Interconnect ID number 541 IN 13 Source type(S,C, or F), Source ID, Source row # S 4 1 C 1 7 542 IN 13 Destination type(A or C), Dest ID, Dest row # 1.7E12 543 IN 13 Gain 14 544 IN 14 Interconnect ID number 545 IN 14 Source type(S,C, or F), Source ID, Source row # C 1 7 A 7 1 546 IN 14 Destination type(A or C), Dest ID, Dest row # 547 IN 14 Gain 15 548 IN 15 Interconnect ID number 549 IN 15 Source type(S,C, or F), Source ID, Source row # S 4 2 550 IN 15 Destination type(A or C), Dest ID, Dest row # C 1 8 1.7E12 551 IN 15 Gain 16 552 IN 16 Interconnect ID number 553 IN 16 Source type(S,C, or F), Source ID, Source row # C 1 8 554 IN 16 Destination type(A or C), Dest ID, Dest row # A 8 1 555 IN 16 Gain 17 556 IN 17 Interconnect ID number 557 IN 17 Source type(S,C, or F), Source ID, Source row # s 4 3 C 1 9 558 IN 17 Destination type(A or C), Dest ID, Dest row # 3.4E12 559 IN 17 Gain 18 560 IN 18 Interconnect ID number 18 Source type(S,C, or F), Source ID, Source row # C 1 9 562 IN 18 Destination type(A or C), Dest ID, Dest row # A 9 1 563 IN 18 Gain 19 564 IN 19 Interconnect ID number 565 IN 19 Source type(S,C, or F), Source ID, Source row # s 5 3 566 IN 19 Destination type(A or C), Dest ID, Dest row # A 10 1 567 IN 19 Gain

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Appendix B

Comparison of Results for ISC Four Control Concepts over Four Seasonal Transitions

Results for the SSP ISC TREETOPS simulation for four control concepts over seasonal transitions are presented in this appendix. In general, time histories of control errors, accelerations, contol torques, power beam force, flexible translations and rotations, hinge forces and hinge torques and relative translations are presented. Concepts reported were concept 1, concept 2A, concept 2B and concept 3. The four seasonal transitions were reported for concept 1 and concept 3: Vernal Equinox, Summer Solstice, Autumnal Equinox and Winter Solstice. For concepts 2A and 2B, only Summer Solstice was reported. The intent was to present the steady-state attributes of the system. Therefore, reported data generally starts at 2 hours, after most of the transients have subsided. Typically, plotted data is reported for 25.8 hrs, just over a day. Also, there are some additional plots with plotted data over a period of approximately 10 days for Vernal Equinox, cases 1 and 3.

In addition, thrust requirements, for control and station keeping, were evaluated and are presented herein. Cumulative thrust curves are presented over a one-day period. Thrust requirements for each control component and for each season are investegated. Tables are also given to summarize the information. One day and one year thrust requirements are presented.

This Appendix is organized as follows:

- TREETOPS simulation results and Thrust Requirements for Concept 1 B.1
- TREETOPS simulation results and Thrust Requirements for Concept 3 **B.2**
- TREETOPS simulation results Comparison of Concept 1, 2A, 2B and 3 and Thrust **B.3** Requirements for Concept 2A and 2B
- Thrust Requirements Comparison for Concept 1, Concept 2A, Concept2B, Concept 3 **B.4** and Stationkeeping

(Later, it was realized that the initial conditions for body 3 and 4 (UC and LC) for concept 1 VE, AE, and WS were not entirely correct. For concept 1 VE, AE and WS, the initial conditions for UC and LC pitch angle were correct, but the initial condition for the UC and LC yaw angle with respect to the boom was not correct. Therefore, Tables B.1-5 through B.1-8 supercede Tables B.1-1 through B.1-4 for concept 1.)

TREETOPS simulation results and Thrust Requirements for Concept 1 **B.1**

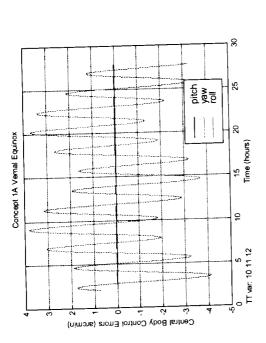


Figure B.1-1a: Central Body Control Errors vs. Time (Vernal Equinox)

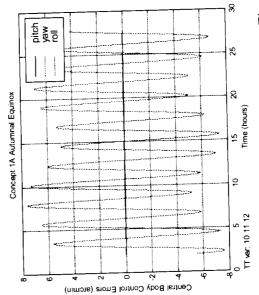


Figure B.1-1c: Central Body Control Errors vs. Time (Autumnal Equinox)

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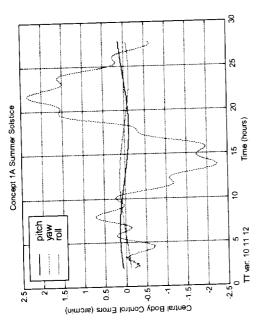


Figure B.1-1b: Central Body Control Errors vs. Time (Summer Solstice)

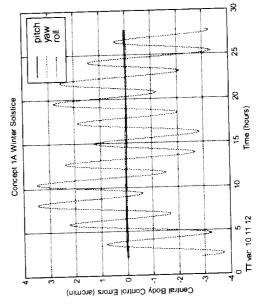


Figure B.1-1d: Central Body Control Errors vs. Time (Winter Solstice)

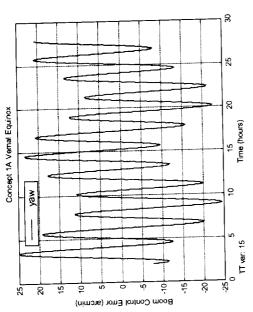


Figure B.1-2a: Boom Control Errors vs. Time (Vernal Equinox)

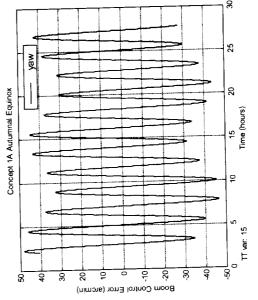


Figure B.1-2c: Boom Control Errors vs. Time (Autumnal Equinox)

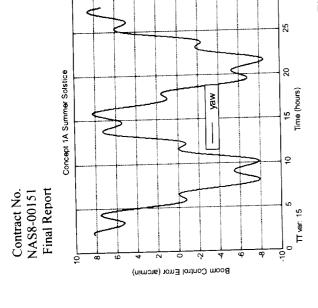


Figure B.1-2b: Boom Control Errors vs. Time (Summer Solstice)

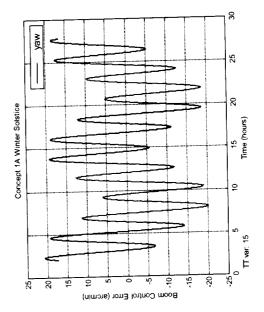


Figure B.1-2d: Boom Control Errors vs. Time (Winter Solstice

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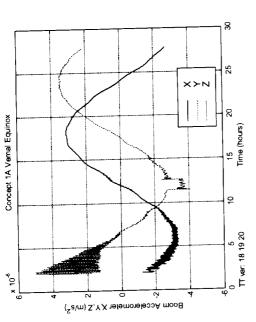


Figure B.1-3a: Boom Accelerometer vs. Time (Vernal Equinox)

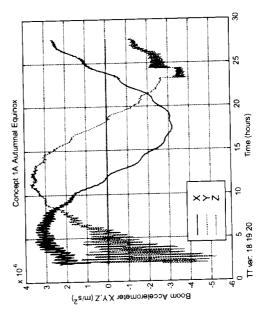


Figure B.1-3c: Boom Accelerometer vs. Time (Autumnal Equinox)

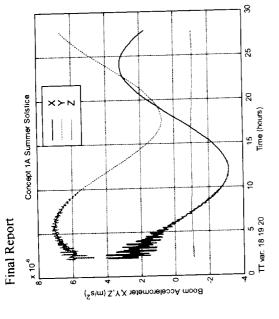


Figure B.1-3b: Boom Accelerometer vs. Time (Summer Solstice)

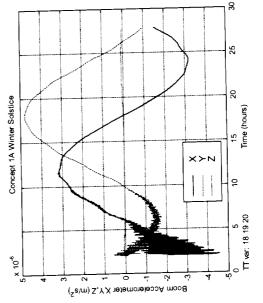


Figure B.1-3d: Boom Accelerometer vs. Time (Winter Solstice)

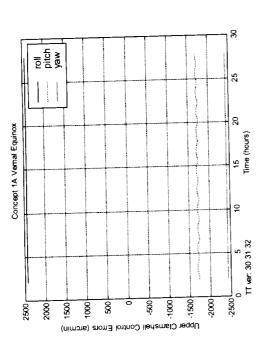


Figure B.1-4a: Upper Clamshell Control Errors vs. Time (Vernal Equinox)

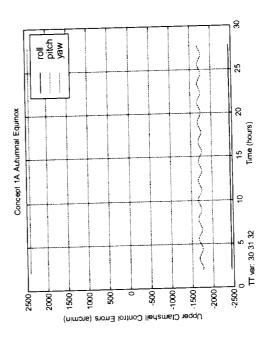


Figure B.1-4c: Upper Clamshell Control Errors vs. Time (Autumnal Equinox)

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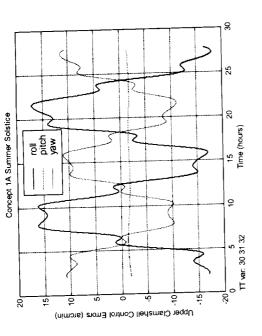


Figure B.1-4b: Upper Clamshell Control Errors vs. Time (Summer Solstice)

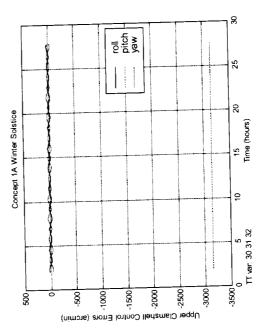


Figure B.1-4d: Upper Clamshell Control Errors vs. Time (Winter Solstice)

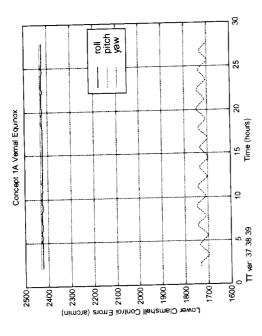


Figure B.1-5a: Lower Clamshell Control Errors vs. Time (Vernal Equinox)

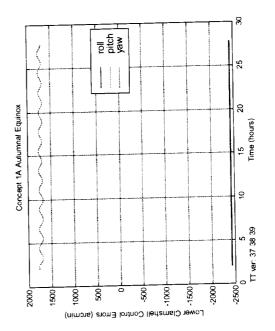


Figure B.1-5c: Lower Clamshell Control Errors vs. Time (Autumnal Equinox)

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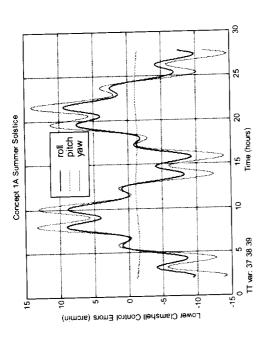


Figure B.1-5b: Lower Clamshell Control Errors vs. Time (Summer Solstice)

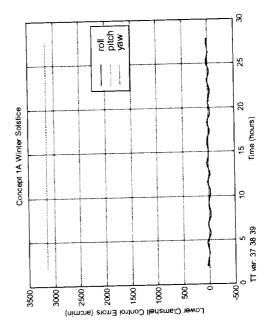


Figure B.1-5d: Lower Clamshell Control Errors vs. Time (Winter Solstice)



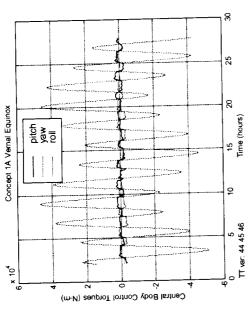


Figure B.1-6a: Central Body Control Torques vs. Time (Vernal Equinox)

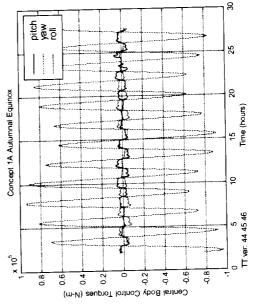


Figure B.1-6c: Central Body Control Torques vs. Time (Autumnal Equinox)

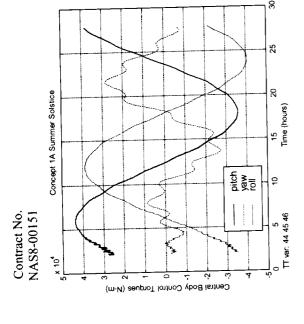


Figure B.1-6b: Central Body Control Torques vs. Time (Summer Solstice)

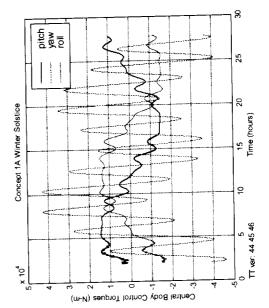


Figure B.1-6d: Central Body Control Torques vs. Time (Winter Solstice)

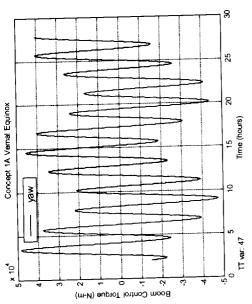


Figure B.1-7a: Boom Control Torques vs. Time (Vernal Equinox)

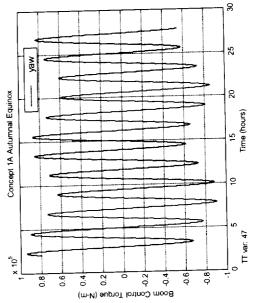


Figure B.1-7c: Boom Control Torques vs. Time (Autumnal Equinox)

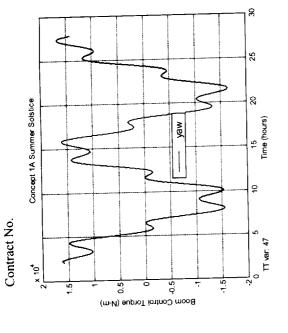


Figure B.1-7b: Boom Control Torques vs. Time (Summer Solstice)

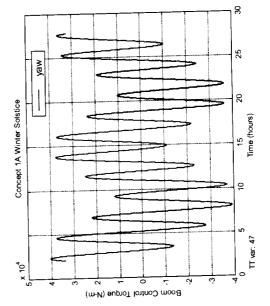


Figure B.1-7d: Boom Control Torques vs. Time (Winter Solstice)



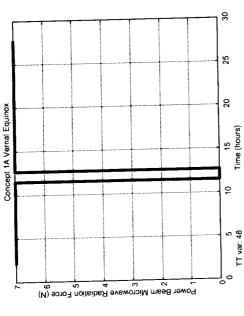


Figure B.1-8a: Power Beam Microwave Radiation Force vs. Time (Vernal Equinox)

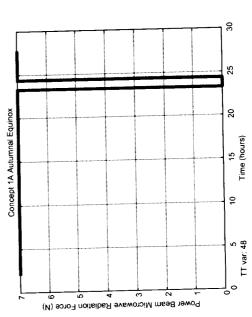


Figure B.1-8c: Power Beam Microwave Radiation Force vs. Time (Autumnal Equinox)

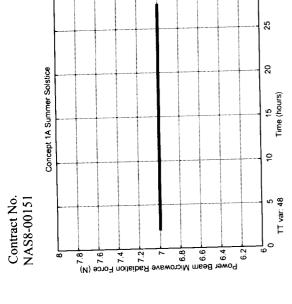


Figure B.1-8b: Power Beam Microwave Radiation Force vs. Time (Summer Solstice)

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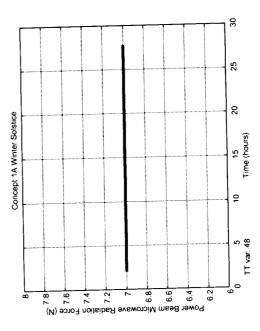


Figure B.1-8d: Power Beam Microwave Radiation Force vs. Time (Winter Solstice)



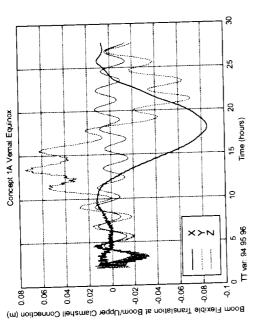


Figure B.1-9a: Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Vernal Equinox)

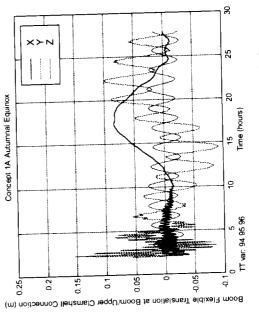


Figure B.1-9c; Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Autumnal Equinox)

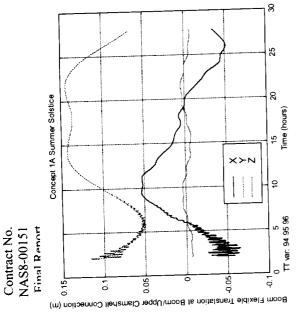


Figure B.1-9b: Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Summer Solstice)

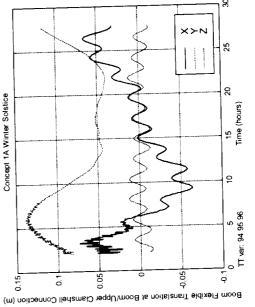
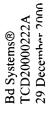


Figure B.1-9d: Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Winter Solstice)



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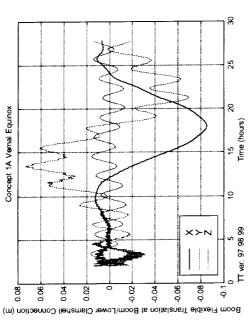


Figure B.1-10a: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Vernal Equinox)

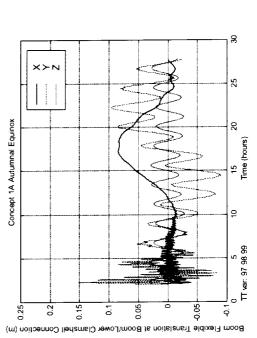


Figure B.1-10c: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Autumnal Equinox)

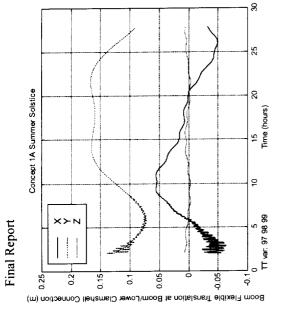


Figure B.1-10b: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Summer Solstice)

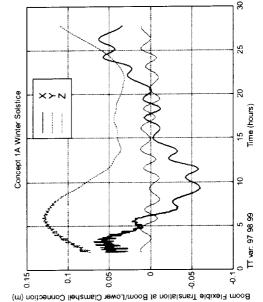


Figure B.1-10d: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Winter Solstice)



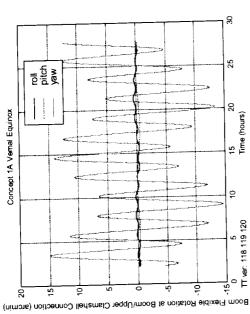


Figure B.1-11a: Boom Flexible Rotation at Boom/Upper Clamshell Connection vs. Time (Vernal Equinox)

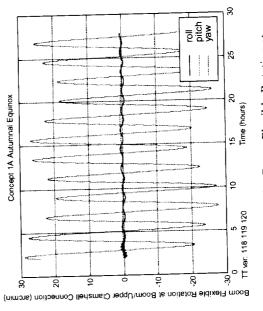


Figure B.1-11c: Boom Flexible Rotation at Boom/Upper Clamshell Connection vs. Time (Autumnal Equinox)

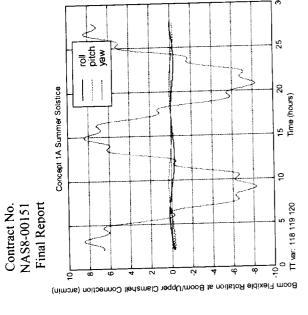


Figure B.1.-11b: Boom Flexible Rotation at Boom/Upper Clamshell Connection vs. Time (Summer Solstice)

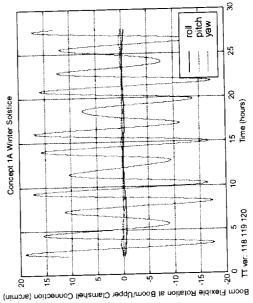


Figure B.1-11d: Boom Flexible Rotation at Boom/Upper Clamshell Connection vs. Time (Winter Solstice)



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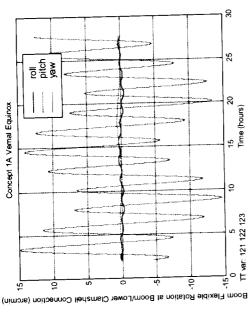


Figure B.1-12a: Boom Flexible Rotation at Boom/Lower Clamshell Connection vs. Time (Vernal Equinox)

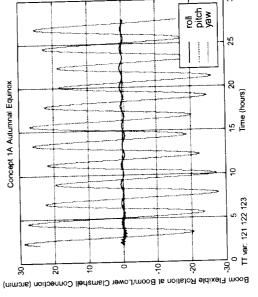


Figure B.1-12c: Boom Flexible Rotation at Boom/Lower Clamshell Connection vs. Time (Autumnal Equinox)

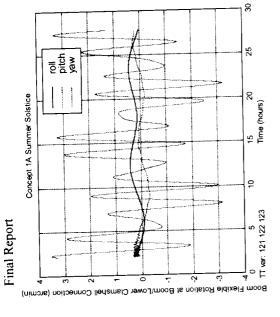


Figure B.1-12b: Boom Flexible Rotation at Boom/Lower Clamshell Connection vs. Time (Summer Solstice)

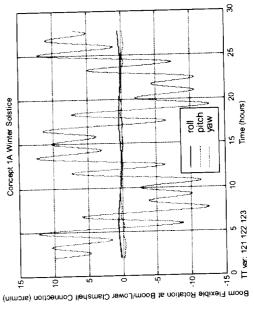


Figure B.1-12d: Boom Flexible Rotation at Boom/Lower Clamshell Connection vs. Time (Winter Solstice)

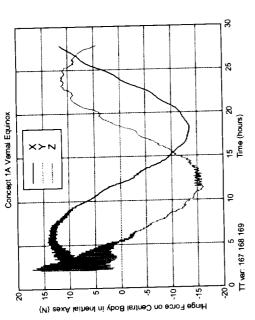


Figure B.1-13a: Hinge Force on Central Body in Inertial Axes vs. Time (Vernal Equinox)

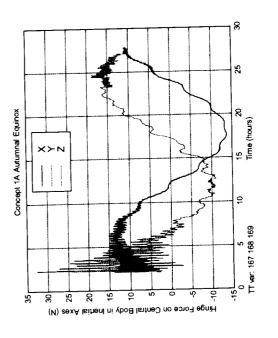


Figure B.1-13c: Hinge Force on Central Body in Inertial Axes vs. Time (Autumnal Equinox)

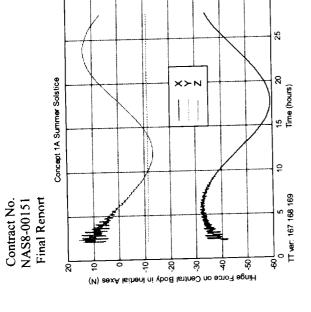


Figure B.1-13b: Hinge Force on Central Body in Inertial Axes vs. Time (Summer Solstice)

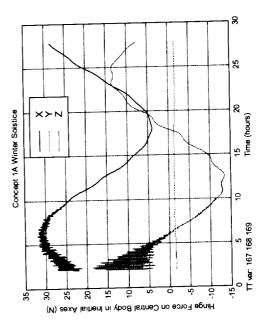


Figure B.1-13d: Hinge Force on Central Body in Inertial Axes vs. Time (Winter Solstice)

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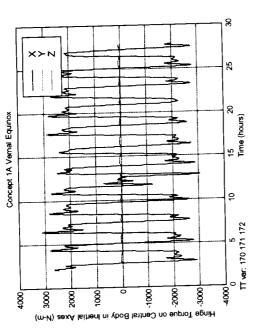


Figure B.1-14a: Hinge Torque on Central Body in Inertial Axes vs. Time (Vernal Equinox)

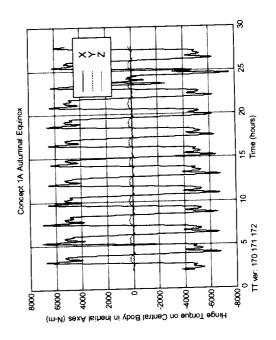


Figure B.1-14c: Hinge Torque on Central Body in Inertial Axes vs. Time (Autumnal Equinox)

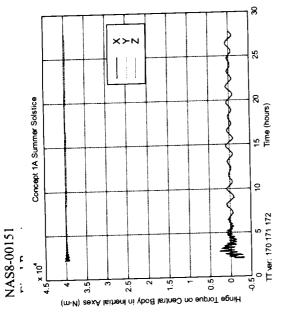


Figure B.1-14b: Hinge Torque on Central Body in Inertial Axes vs. Time (Summer Solstice)

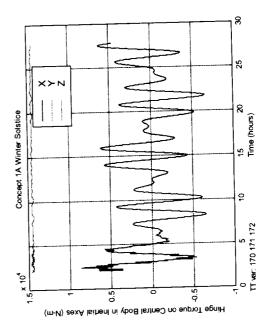


Figure B.1-14d: Hinge Torque on Central Body in Inertial Axes vs. Time (Winter Solstice)

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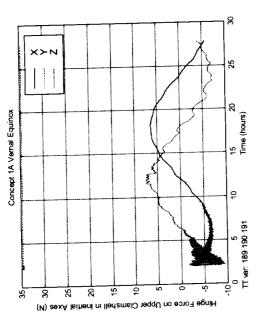


Figure B.1-15a: Hinge Force on Upper Clamshell in Inertial Axes vs. Time (Vernal Equinox)

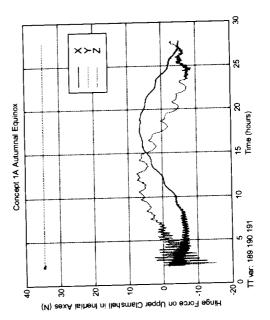


Figure B.1-15c: Hinge Force on Upper Clamshell in Inertial Axes vs. Time (Autumnal Equinox)

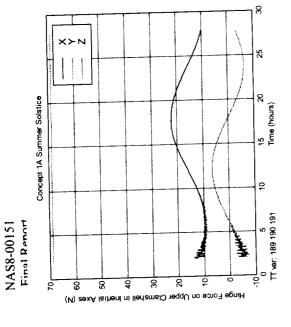


Figure B.1-15b: Hinge Force on Upper Clamshell in Inertial Axes vs. Time (Summer Solstice)

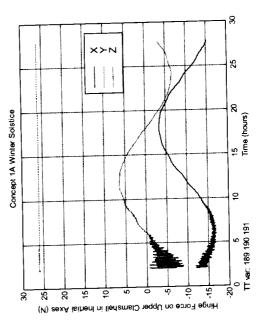


Figure B.1-15d: Hinge Force on Upper clamshell in Inertial Axes vs. Time (Winter Solstice)

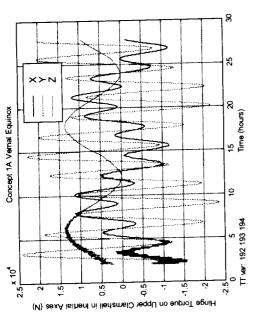


Figure B.1-16a: Hinge Torque on Upper Clamshell in Inertial Axes vs. Time (Vernal Equinox)

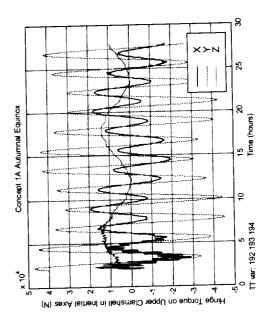


Figure B.1-16c: Hinge Torque on Upper Clamshell in Inertial Axes vs. Time (Autumnal Equinox)

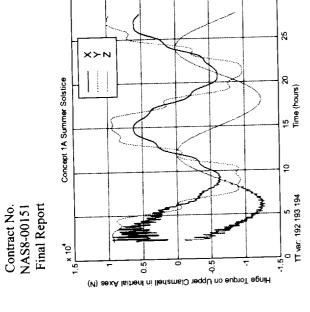


Figure B.1-16b: Hinge Torque on Upper Clamshell in Inertial Axes vs. Time (Summer Solstice)

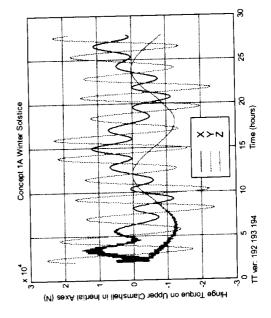


Figure B.1-16d: Hinge Torque on Upper Clamshell in Inertial Axes vs. Time (Winter Solstice)

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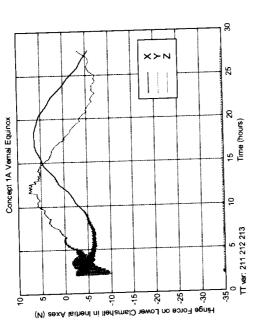


Figure B.1-17a: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Vernal Equinox)

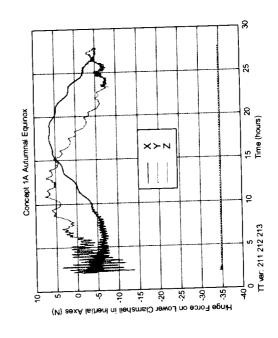


Figure B.1-17c: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Autumnal Equinox)

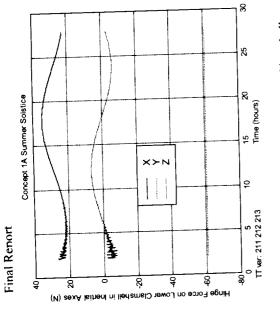


Figure B.1-17b: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Summer Solstice)

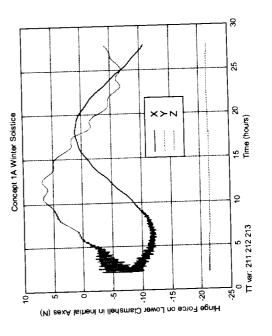


Figure B.1-17d: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Winter Solstice)



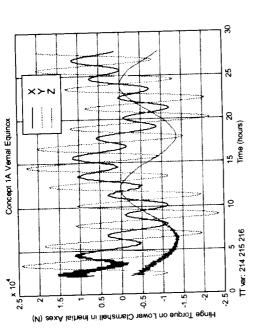


Figure B.1-18a: Hinge Torque on Lower Clamshell in Inertial Axes vs. Time (Vernal Equinox)

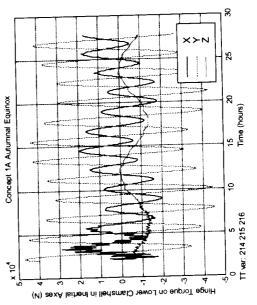


Figure B.1-18c: Hinge Torque on Lower Clamshell in Inertial Axes vs. Time (Autumnal Equinox)

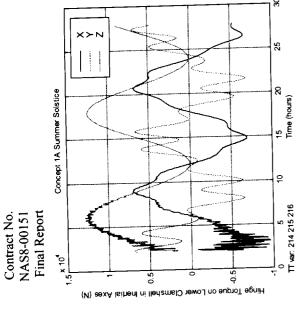


Figure B.1-18b: Hinge Torque on Lower Clamshell in Inertial Axes vs. Time (Summer Solstice)

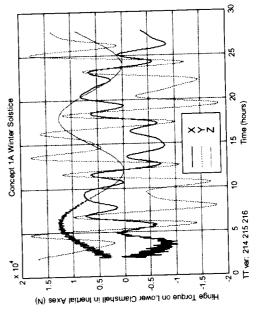


Figure B.1-18d: Hinge Torque on Lower Clamshell in Inertial Axes vs. Time (Winter Solstice)

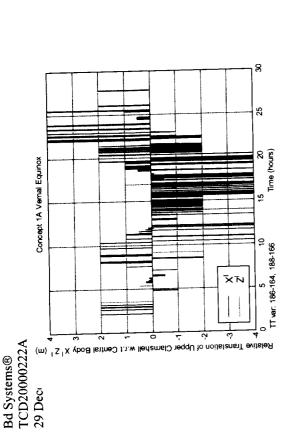


Figure B.1-19a: Relative Translation of Upper Clamshell w.r.t. Central Body vs. Time (Vernal Equinox)

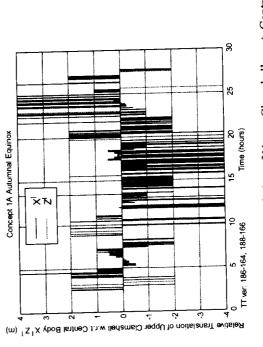


Figure B.1-19c: Relative Translation of Upper Clamshell w.r.t. Central Body vs. Time (Autumnal Equinox)

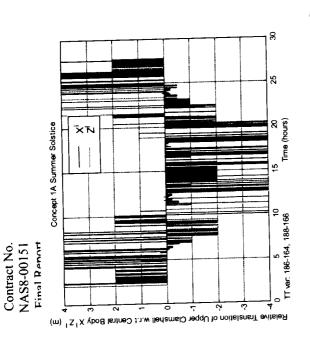


Figure B.1-19b: Relative Translation of Upper Clamshell w.r.t. Central Body vs. Time (Summer Solstice)

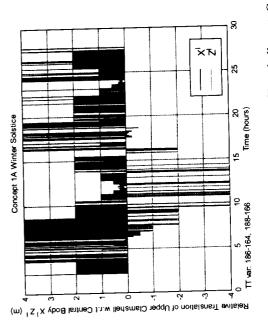


Figure B.1-19d: Relative Translation of Upper Clamshell w.r.t. Central Body vs. Time (Winter Solstice)

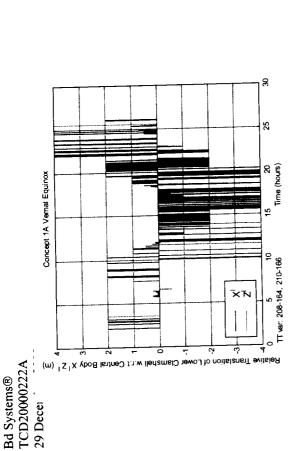


Figure B.1-20a: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Vernal Equinox)

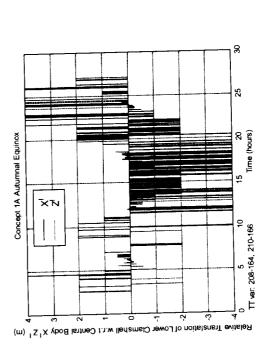


Figure B.1-20c: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Autumnal Equinox)

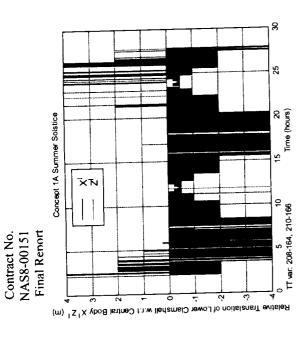


Figure B.1-20b: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Summer Solstice)

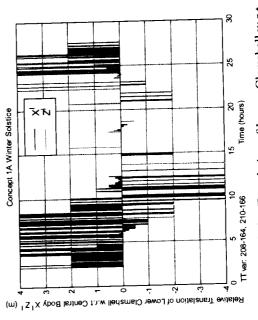


Figure B. 1-20d: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Winter Solstice)

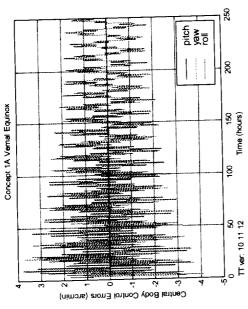


Figure B.1-21: Central Body Control Errors vs. Time (Vernal Equinox)

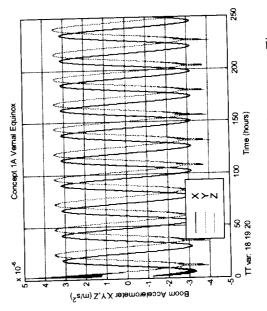


Figure B.1-23: Boom Accelerometer vs. Time (Vernal Equinox)

Contract No.

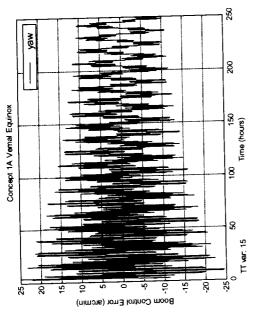


Figure B.1-22: Boom Control Errors vs. Time (Vernal Equinox)

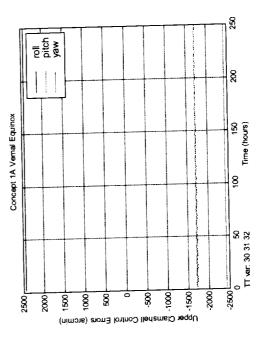


Figure B.1-24: Upper Clamshell Control Errors vs. Time (Vernal Equinox)

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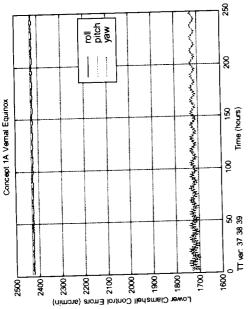


Figure B.1-25: Lower Clamshell Control Errors vs. Time (Vernal Equinox)

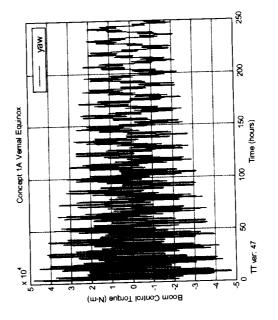


Figure B.1-27: Boom Control Torques vs. Time (Vernal Equinox)

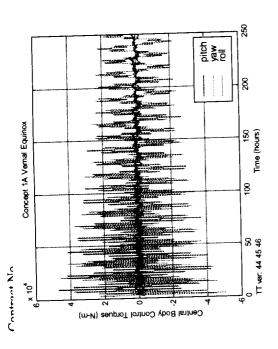


Figure B.1-26: Central Body Control Torques vs. Time (Vernal Equinox)

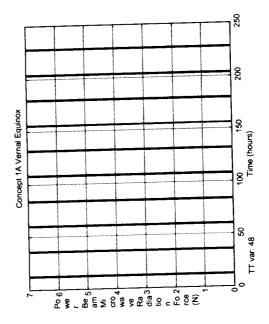


Figure B.1-28: Power Beam Microwave Radiation Force vs. Time (Vernal Equinox)



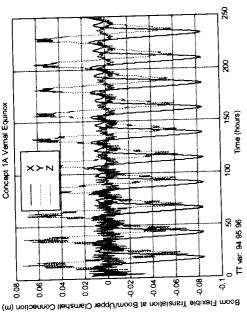


Figure B.1-29: Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Vernal Equinox)

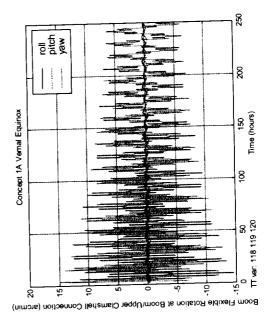


Figure B.1-31: Boom Flexible Rotation at Boom/Upper Clamshell Connection vs. Time (Vernal Equinox)

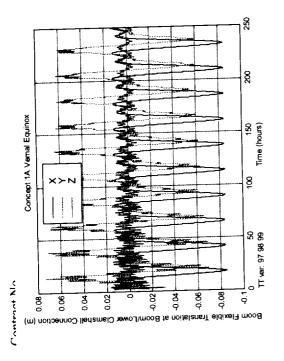


Figure B.1-30: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Vernal Equinox)

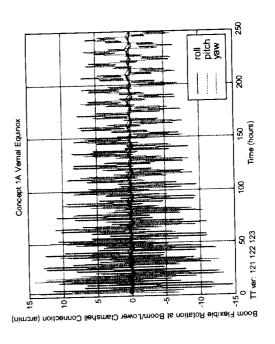


Figure B.1-32: Boom Flexible Rotation at Boom/Lower Clamshell Connection vs. Time (Vernal Equinox)

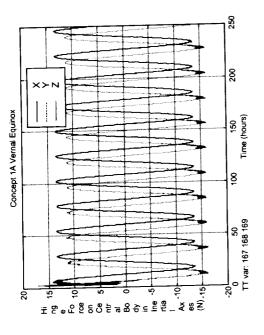


Figure B.1-33: Hinge Force on Central Body in Inertial Axes vs. Time (Vernal Equinox)

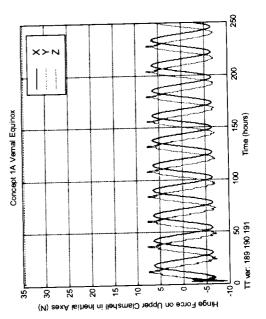


Figure B.1-35: Hinge Force on Upper Clamshell in Inertial Axes vs. Time (Vernal Equinox)

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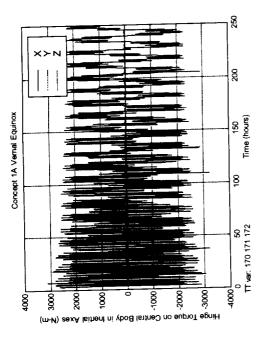


Figure B.1-34: Hinge Torque on Central Body in Inertial Axes vs. Time (Vernal Equinox)

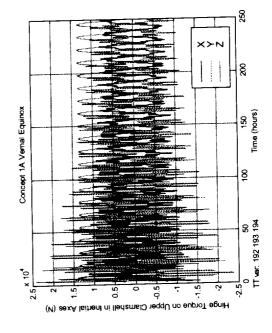


Figure B.1-36: Hinge Torque on Upper Clamshell in Inertial Axes vs. Time (Vernal Equinox)

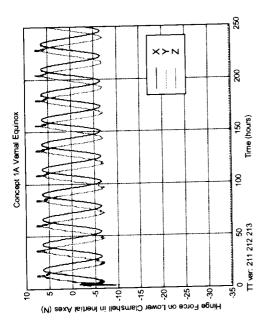


Figure B.1-37: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Vernal Equinox)

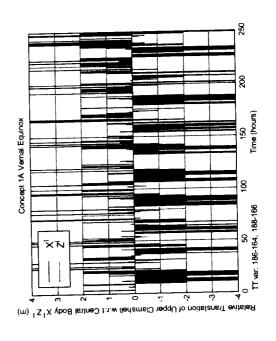


Figure B.1-39: Relative Translation of Upper Clamshell w.r.t. Central Body vs. Time (Vernal Equinox)



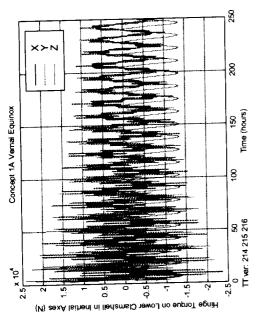


Figure B.1-38: Hinge Torque on Lower Clamshell in Inertial Axes vs. Time (Vernal Equinox)

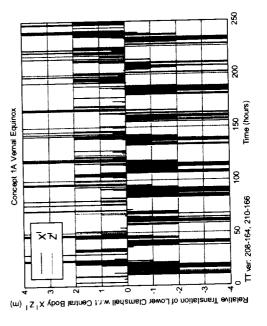


Figure B.1-40: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Vernal Equinox)

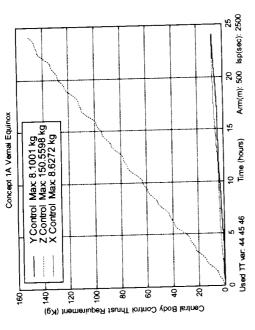


Figure B.1-41a: Central Body Control Thrust Requirement vs. Time for 1 Day (Vernal Equinox)

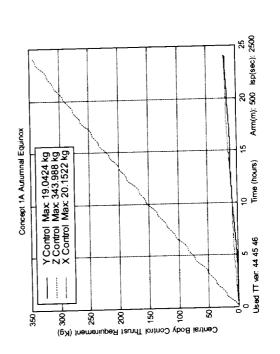


Figure B.1-41c: Central Body Control Thrust Requirement vs. Time for 1 Day (Autumnal Equinox)

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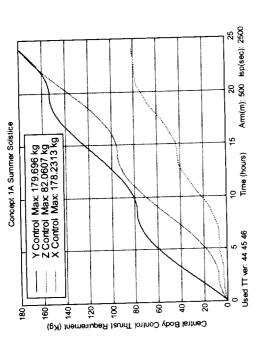


Figure B.1-41a: Central Body Control Thrust Requirement vs. Time for 1 Day (Summer Solstice)

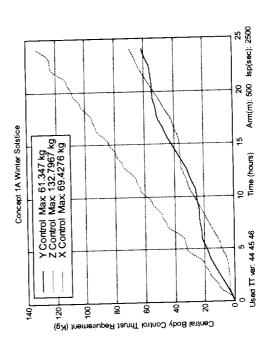


Figure B.1-41d: Central Body Control Thrust Requirement vs. Time for 1 Day (Winter Solstice)

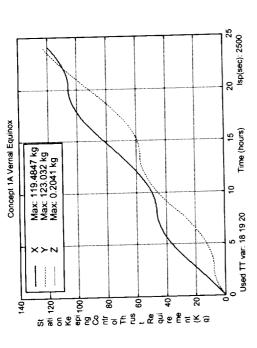


Figure B.1-42a: Station Keeping Control Thrust Requirement vs. Time for 1 Day
(Vernal Equinox)

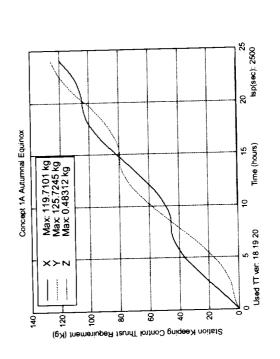


Figure B.1-42c: Station Keeping Control Thrust Requirement vs. Time for 1 Day (Autumnal Equinox)

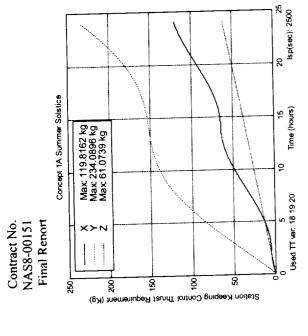


Figure B.1-42b: Station Keeping Clamshell Control Thrust Requirement vs. Time for 1 Day (Summer Solstice)

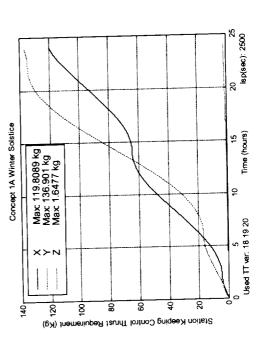


Figure B.1-42d: Station Keeping Control Thrust Requirement vs. Time for 1 Day
(Winter Solstice)

		Total	313.508
	əgt	Z Control	555.771
	Daily Average	Y Control	67.046
.1-5)	Ds	X Control	911.09
Thrust Requirements (Kg) (Concept 1) (Now Obsolete, See Table B.1-5)	tice	Z X Y Z Y Z X Y Z X Y Control Control Control Control Control Control	132,707
solete, Se	Winter Solstice	y Control	61.347
Now Ob	M.	X Control	69.428
ncept 1) (inox	Z Control	343.988
(Kg) (Co	Autumnal Equinox	y Control	10.043
irements	Autu	X Control	
rust Requ	ice	Z Control	82.061
Daily Th	Summer Solstice	Y Control	179.696 82.061 20.152
Predicted	Sum	X Control	178.231
Table B.1-1: Predicted Daily	you	X Y Z X Control Control Control	150.560
Ë	Vernal Equinox	Y Control	81-8
	Ve	X Control	£ €9.8
		Description	Central Body Control

Notes:

1) Assumptions: Isp = 2500. Sec; Thrusters moment arm on Central Body = 500 m

2) In reference to crossed-out numbers above, it was later determined that the initial condition for Concept 1 L1(Z^B) should have been 90 deg for all cases.

				\Box
	,	Total	200.494	
	şe	Z	588.21	
(9-	Daily Average	>	154,037	
Table B.1	Da	×	\$02'611	
lete, See	ec	Z	849**	
Now Obso	Winter Solstice	Y	136.001	
ncept 1) (1	Win	×	110.800	
ping (Co	nox	Z	483	
tation Kee	Autumnal Equinox	>-	522:301	
Table B.1-2: Predicted Daily Thrust Requirements (Kg) for Station Keeping (Concept 1) (Now Obsolete, See Table B.1-6)	Autur	×		
irements (es	Z	61.074	
ırust Requ	Summer Solstice	>	119.816 234.090 61.074 +19.719	
d Daily Th	Sum	×	119.816	
Predicte	×c	Z	100	
ble B.1-2:	Vernal Equinox	>	250.551	
Ta	Ver	×	119.485	
		Description	Station Keeping	Control

1) Assumptions: Isp = 2500. Sec; Total System Mass = 16921186.33 kg2) In reference to crossed-out numbers above, it was later determined that the initial condition for Concept 1 L1(Z^B) should have been 90 deg for all cases.

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	TABLE B.1-	-3: Predicted Daily	and Yearly Thrus	TABLE B.1-3: Predicted Daily and Yearly Thrust Requirements (Kg) (Concept 1) (Now Obsolete, See Table B.1-7)	g) (Concept 1) (No	w Obsolete, See T	able B.1-7)	
	Daily Total					Yearly Total	Total	
								Total
Description	X Control	Y Control	Z Control	Total (1 Day)	X Control	Y Control	Z Control	(1 Year)
Central Body Control	911.69	67.046	177.353	313.508	25242.	24489.	64779.	114510.

Notes:

1) Assumptions: Isp = 2500. Sec; Thrusters moment arm on Central Body = 500 m

2) I Year = 365.25 days

3) In reference to crossed-out numbers above, it was later determined that the initial condition for Concept 1 L1(Z^B) should have been 90 deg for all cases.

Daily Total Yearly Total Yearly Total Total X Y Z (1 May) X X Y Z (1 May) X	TABL	E B.1-4: Predict	ed Daily and Year	ly Thrust Requirer	nents for Station K	eeping (Kg) (Conc	TABLE B.1-4: Predicted Daily and Yearly Thrust Requirements for Station Keeping (Kg) (Concept 1) (Now Obsolete, See Table B.1-8)	lete, See Table B.	1-8)
X Y Z Total X Y Z 110.705 154.937 15.853 200.404 43722. \$6591. 5790.		Daily Total					Yearly	Total	
X Y Z 10tal (1 Day) X Y Z 119,705 154,937 15,852 200,494 43722. \$6591. 5790.									Total
110.705 154.037 15.853 200.404 43722. 56591.	Description	×	>	Z	Total (1 Day)	X	>	Z	(1 Year)
	Station Keeping Control	\$02.011	154.937	75851	390.494	43733.	10595	\$790.	106103.

Notes:

1) Assumptions: Isp = 2500. Sec; Total System Mass = 16921186.33 kg 2) 1 Year = 365.25 days

3) In reference to crossed-out numbers above, it was later determined that the initial condition for Concept 1 L1(Z^B) should have been 90 deg for all cases.

	_ 		al		210		_
		_	Total	\vdash	269.610		
	ge		Z Control		86.300		
	Daily Average		Y Control		91.463 91.847		
	Da		X Control		91.463		
	ice		X Y Z X Y Control Control Control Control		178.2 179.5 82.04		
cept 1)	Winter Solstice	(est.)	Y Control		179.5		
Kg) (Conc	Wil		X Control		178.2		
Table B.1-5: Predicted Daily Thrust Requirements (Kg) (Concept 1)	inox		Z Y Y Z Control Control Control		9.06		
ust Requi	Autumnal Equinox	(est.)	Y Control		5.31		
Jaily Thr	Autu		X Control		5.53		
edicted L	es		Z Control		696 82.061 5.53		
B.1-5: Pr	Summer Solstice	(calc.)	Y Control		179.696		
Table	Sum		X Control		178.231 179.6		
	×oc		Z X Control Control		\$ 06		
	/ernal Follinox	(est.)	X Y Control		2 88	20:-	
	>		X Control		3 80	7.07	
			Description		Central Body	Control	Notos:

Notes:

1) Assumptions: Isp = 2500. Sec; Thrusters moment arm on Central Body = 500 m 2) Est. = Estimated using (Summer Solstice calc 1/Summer Solstice calc 3)x(calc 3) for each case and component.

			Table	e B.1-6: P	Table B.1-6: Predicted Daily Thrust Requirements (Kg) for Station Keeping (Concept 1)	aily Thru	st Require	ments (Kg	g) for Stat	ion Keepi	ng (Conce	pt 1)				
	Ver	Vernal Equinox	×c	Sum	Summer Solstice	ice	Autui	Autumnal Equinox (est.)	nox	Wir	Winter Solstice (est.)	ę,	Dai	Daily Average	v	,
		(est.)			(Carre											Total
Description	×	>	Z	×	>	Z	×	>	Z	×	*	Z	×	Y	Z	
Station Keening	130.2	258.5	.762	119.816	234.090	61.074 139.4	139.4	258.9 1.778	1.778	120.2	234.11	61.074	127.404	234.11 61.074 127.404 246.400 31.172 404.976	31.172	404.976
Control																

Notes:
1) Assumptions: Isp = 2500. Sec; Total System Mass = 16921186.33 kg
2) Est. = Estimated using (Summer Solstice calc 1/Summer Solstice calc 3)x(calc 3) for each case and component.

		TABLE B.1-7: 1	7: Predicted Daily	Predicted Daily and Yearly Thrust Requirements (Kg) (Concept 1)	Requirements (Kg	(Concept 1)		
		Daily	y Total			Yearly Total	Total	
								Total
Description	X Control	Y Control	Z Control	Total (1 Day)	X Control	Y Control	Z Control	(1 Year)
Central Body Control	91.463	91.847	86.300	269.610	33407.	33547.	31521.	98475.

Notes:

Assumptions: Isp = 2500. Sec; Thrusters moment arm on Central Body = 500 m
 Est. = Estimated using (Summer Solstice calc 1/Summer Solstice calc 3)x(calc 3) for each case and component.
 I Year = 365.25 days

	TABI	TABLE B.1-8: Predicted I	d Daily and Yearly	Thrust Requireme	ents for Station Ke	Daily and Yearly Thrust Requirements for Station Keeping (Kg) (Concept 1)	pt 1)	
		Daily	y Total			Yearly Total	. Total	
								Total
Description	×	¥	Z	Total (1 Day)	×	Υ	Z	(1 Year)
Station Keeping Control	127.404	246.400	31.172	404.976	46534.	86668.	11386.	147918.

1) Assumptions: Isp = 2500. Sec; Total System Mass = 16921186.33 kg
2) Est. = Estimated using (Summer Solstice calc 1/Summer Solstice calc 3)x(calc 3) for each case and component.
3) I Year = 365.25 days

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B.2 - TREETOPS simulation results and Thrust Requirements for Concept 3

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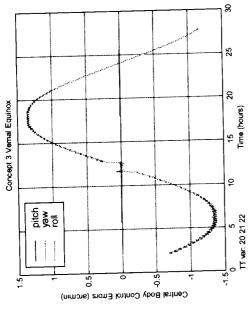


Figure B.2-1a: Central Body Control Errors vs. Time (Vernal Equinox)

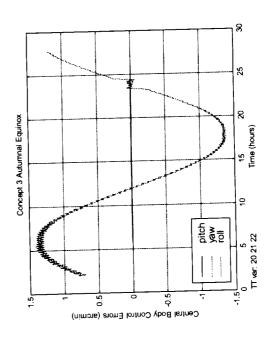


Figure B.2-1c: Central Body Control Errors vs. Time (Autumnal Equinox)

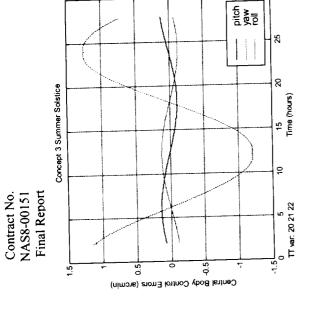


Figure B.2-1b: Central Body Control Errors vs. Time (Summer Solstice)

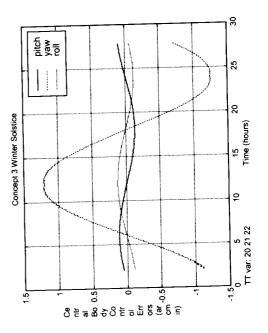


Figure B.2-1d: Central Body Control Errors vs. Time (Winter Solstice)

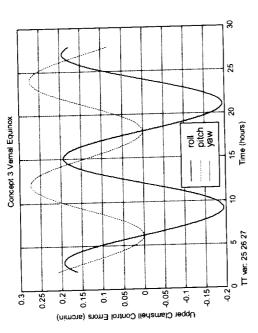


Figure B.2-2a: Upper Clamshell Control Errors vs. Time (Vernal Equinox)

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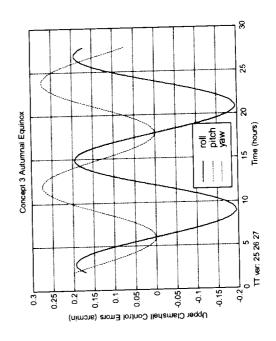


Figure B.2-2c: Upper Clamshell Control Errors vs. Time (Autumnal Equinox)

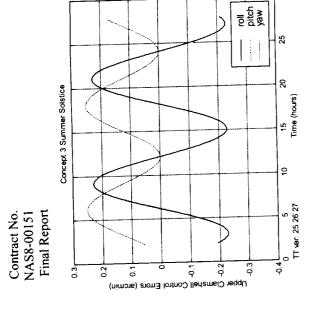


Figure B.2-2b: Upper Clamshell Control Errors vs. Time (Summer Solstice)

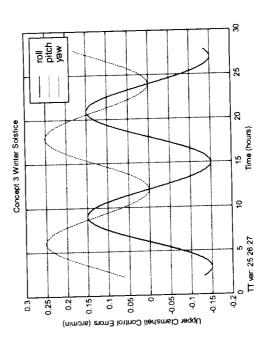


Figure B.2-2d: Upper Clamshell Control Errors vs. Time (Winter Solstice)

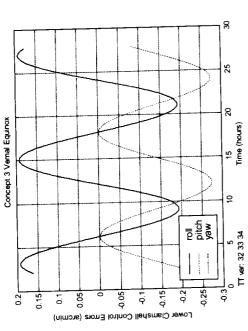


Figure B.2-3a: Lower Clamshell Control Errors vs. Time (Vernal Equinox)

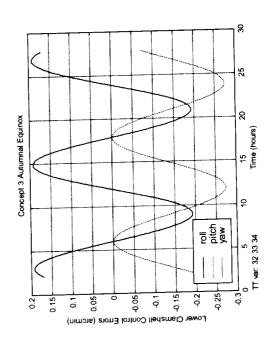


Figure B.2-3c: Lower Clamshell Control Errors vs. Time (Autumnal Equinox)



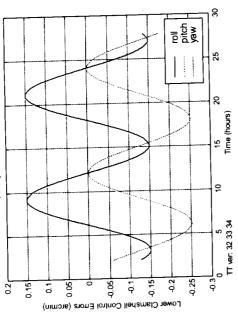


Figure B.2-3b: Lower Clamshell Control Errors vs. Time (Summer Solstice)

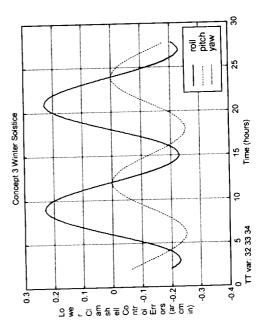


Figure B.2-3d: Lower Clamshell Control Errors vs. Time (Winter Solstice)



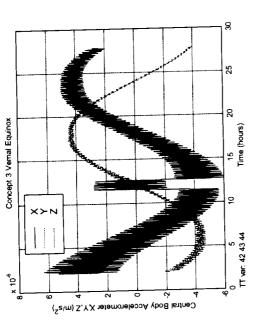


Figure B.2-4a: Central Body Accelerometer vs. Time (Vernal Equinox)

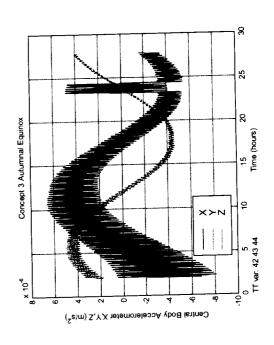


Figure B.2-4c: Central Body Accelerometer vs. Time (Autumnal Equinox)

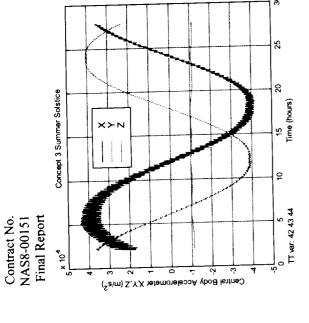


Figure B.2-4b: Central Body Accelerometer vs. Time (Summer Solstice)

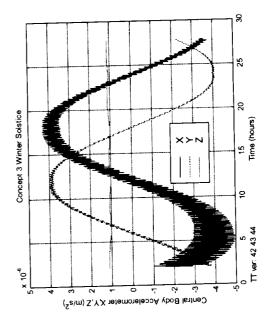


Figure B.2-4d: Central Body Accelerometer vs. Time (Winter Solstice)



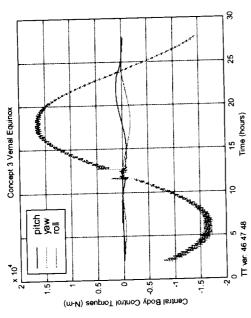


Figure B.2-5a: Central Body Control Torques vs. Time (Vernal Equinox)

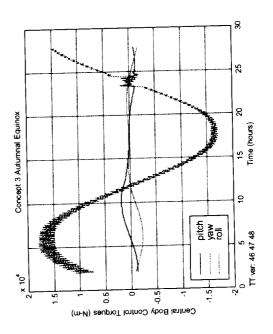


Figure B.2-5c: Central Body Control Torques vs. Time (Autumnal Equinox)

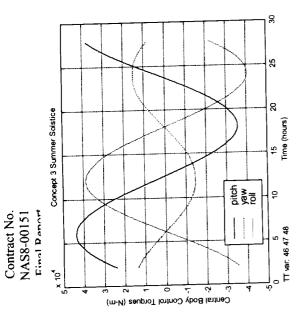


Figure B.2-5b: Central Body Control Torques vs. Time (Summer Solstice)

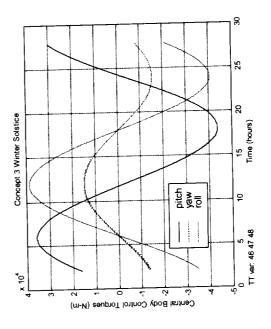


Figure B.2-5d: Central Body Control Torques vs. Time (Winter Solstice)

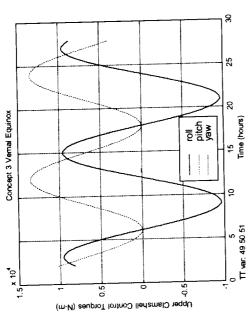


Figure B.2-6a: Upper Clamshell Control Torques vs. Time (Vernal Equinox)

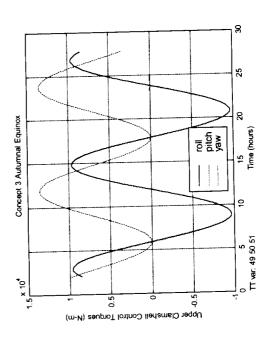


Figure B.2-6c: Upper Clamshell Control Torques vs. Time (Autumnal Equinox)

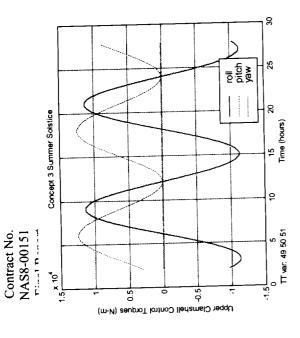


Figure B.2-6b: Upper Clamshell Control Torques vs. Time (Summer Solstice)

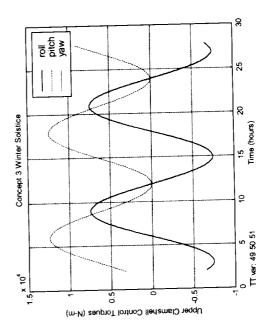


Figure B.2-6d: Upper Clamshell Control Torques vs. Time (Winter Solstice)

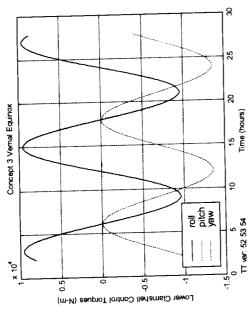


Figure B.2-7a: Lower Clamshell Control Torques vs. Time (Vernal Equinox)

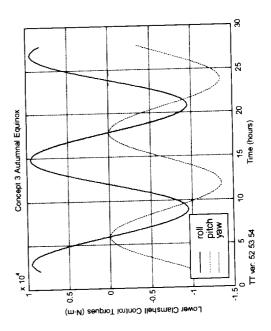


Figure B.2-7c: Lower Clamshell Control Torques vs. Time (Autumnal Equinox)

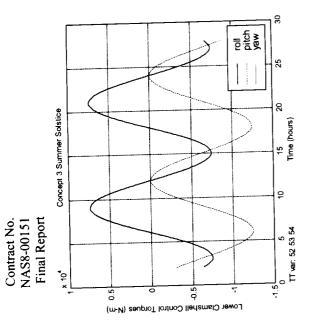


Figure B.2-7b: Lower Clamshell Control Torques vs. Time (Summer Solstice)

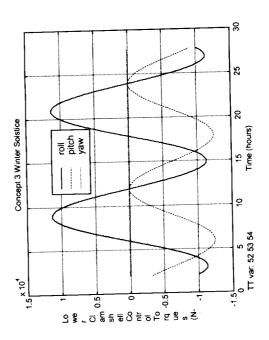


Figure B.2-7d: Lower Clamshell Control Torques vs. Time (Winter Solstice)

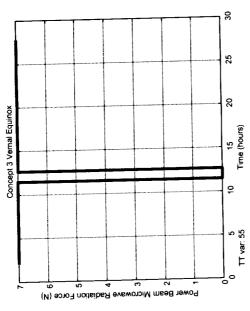


Figure B.2-8a: Power Beam Microwave Radiation Force vs. Time (Vernal Equinox)

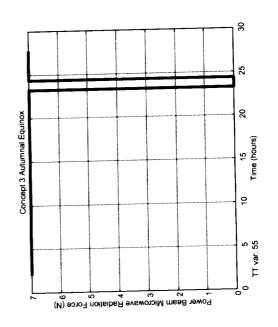


Figure B.2-8c: Power Beam Microwave Radiation Force vs. Time (Autumnal Equinox)

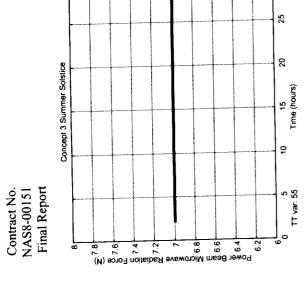


Figure B.2-8b: Power Beam Microwave Radiation Force vs. Time (Summer Solstice)

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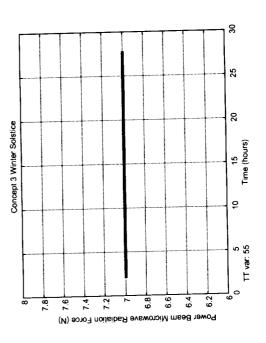


Figure B.2-8d: Power Beam Microwave Radiation Force vs. Time (Winter Solstice)



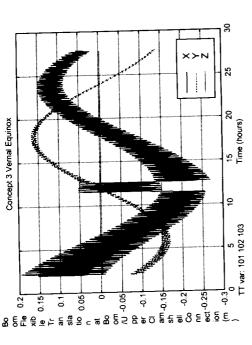


Figure B.2-9a: Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Vernal Equinox)

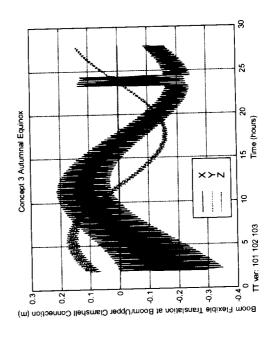


Figure B.2-9c: Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Autumnal Equinox)

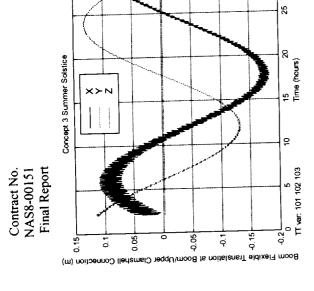


Figure B.2-9b: Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Summer Solstice)

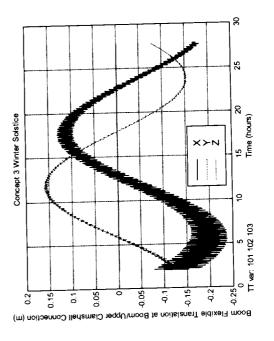


Figure B.2-9d: Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Winter Solstice)

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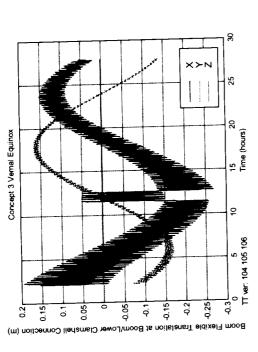


Figure B.2-10a: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Vernal Equinox)

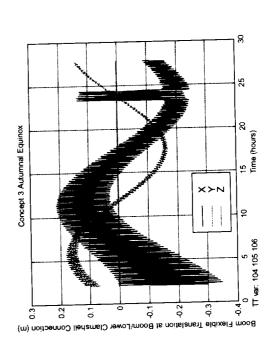


Figure B.2-10c: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Autumnal Equinox)

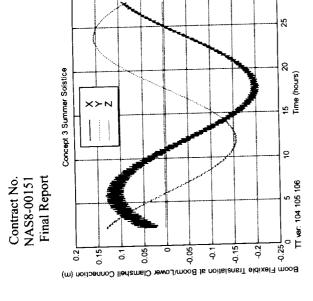


Figure B.2-10b: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Summer Solstice)

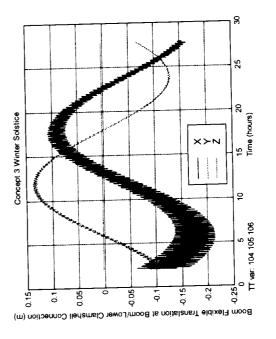
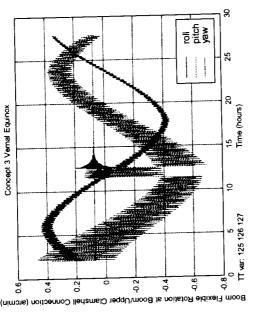


Figure B.2-10d: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Winter Solstice)



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Boom/Upper Clamshell Connection vs. Time Figure B.2-11a: Boom Flexible Rotation at (Vernal Equinox)

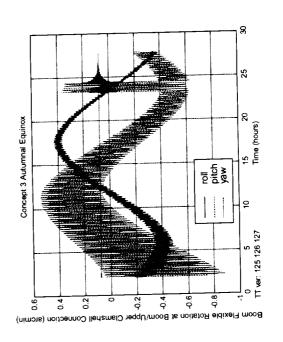


Figure B.2-11c: Boom Flexible Rotation at Boom/Upper Clamshell Connection vs. Time (Autumnal Equinox)

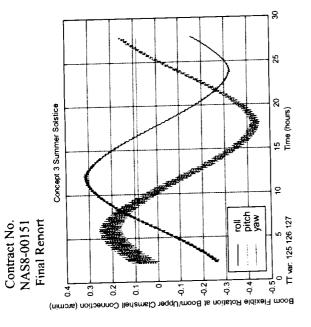


Figure B.2-11b: Boom Flexible Rotation at Boom/Upper Clamshell Connection vs. Time (Summer Solstice)

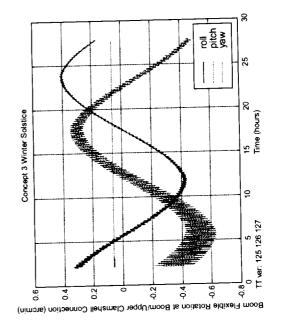
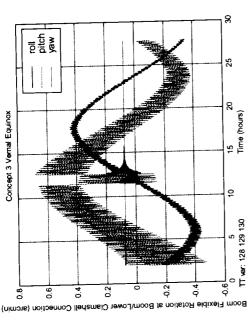
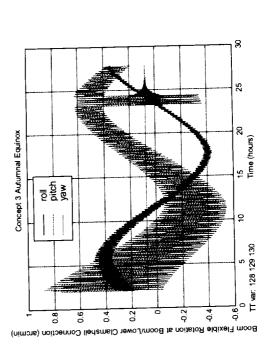


Figure B.2-11d: Boom Flexible Rotation at Boom/Upper Clamshell Connection vs. Time (Winter Solstice)





Boom/Lower Clamshell Connection vs. Time Figure B.2-12a: Boom Flexible Rotation at (Vernal Equinox)



Boom/Lower Clamshell Connection vs. Time Figure B.2-12c: Boom Flexible Rotation at (Autumnal Equinox)

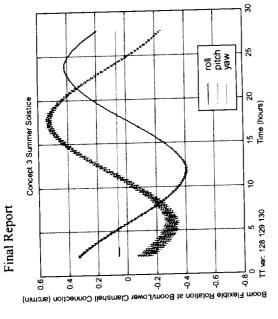


Figure B.2-12b: Boom Flexible Rotation at Boom/Lower Clamshell Connection vs. Time (Summer Solstice)

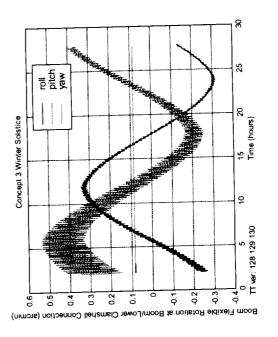


Figure B.2-12d: Boom Flexible Rotation at Boom/Lower Clamshell Connection vs. Time (Winter Solstice)

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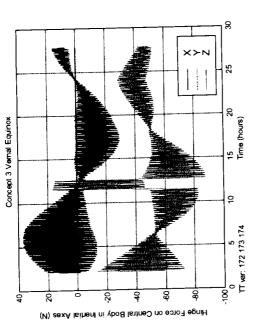


Figure B.2-13a: Hinge Force on Central Body in Inertial Axes vs. Time (Vernal Equinox)

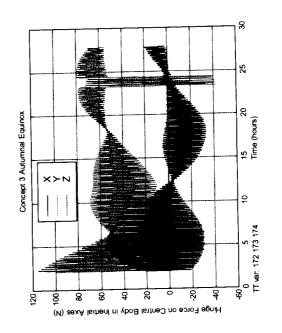


Figure B.2-13c: Hinge Force on Central Body in Inertial Axes vs. Time (Autumnal Equinox)

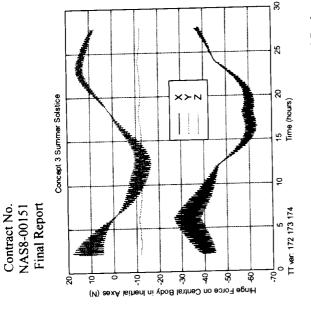


Figure B.2-13b: Hinge Force on Central Body in Inertial Axes vs. Time (Summer Solstice)

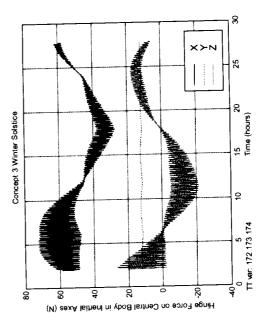


Figure B.2-13d: Hinge Force on Central Body in Inertial Axes vs. Time (Winter Solstice)

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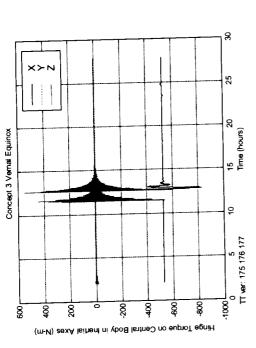


Figure B.2-14a: Hinge Torque on Central Body in Inertial Axes vs. Time (Vernal Equinox)

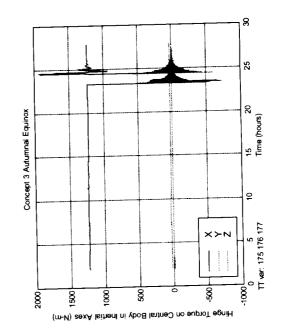


Figure B.2-14c: Hinge Torque on Central Body in Inertial Axes vs. Time (Autumnal Equinox)

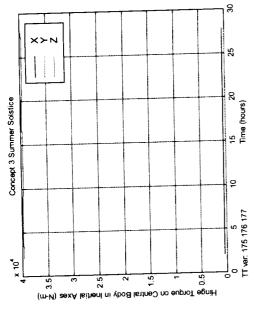


Figure B.2-14b: Hinge Torque on Central Body in Inertial Axes vs. Time (Summer Solstice)

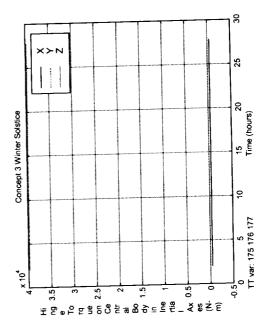


Figure B.2-14d: Hinge Torque on Central Body in Inertial Axes vs. Time (Winter Solstice)

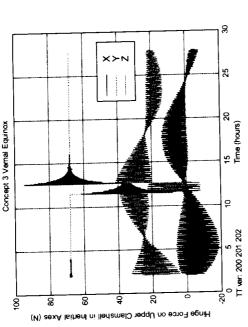


Figure B.2-15a: Hinge Force on Upper Clamshell in Inertial Axes vs. Time (Vernal Equinox)

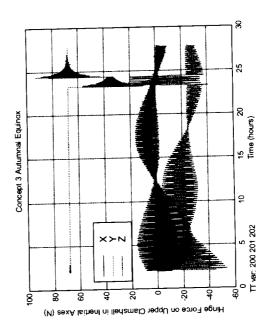


Figure B.2-15c: Hinge Force on Upper Clamshell in Inertial Axes vs. Time (Autumnal Equinox)

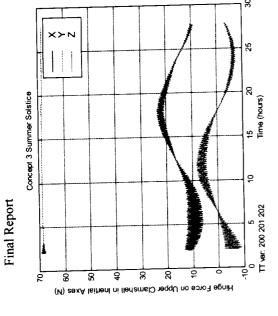


Figure B.2-15b: Hinge Force on Upper Clamshell in Inertial Axes vs. Time (Summer Solstice)

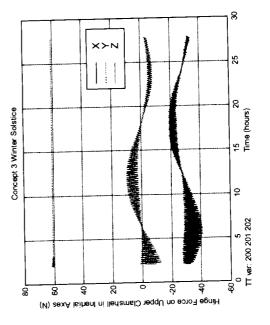


Figure B.2-15d: Hinge Force on Upper Clamshell in Inertial Axes vs. Time (Winter Solstice)

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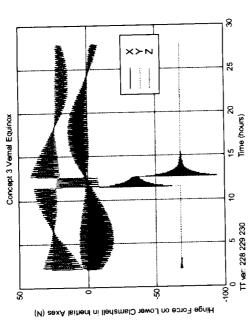


Figure B.2-16a: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Vernal Equinox)

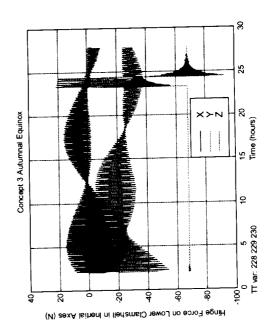


Figure B.2-16c: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Autumnal Equinox)

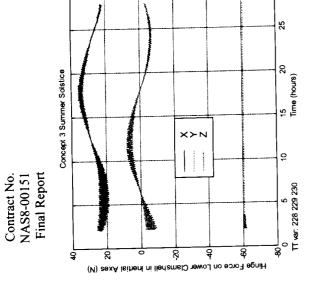


Figure B.2-16b: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Summer Solstice)

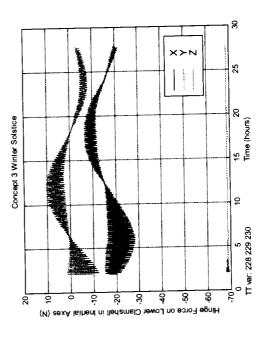


Figure B.2-16d: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Winter Solstice)

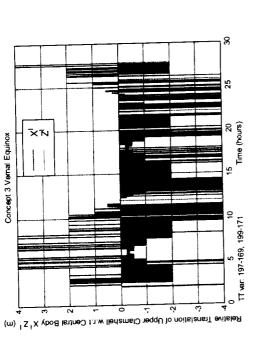


Figure B.2-17a: Relative Translation of Upper Clamshell w.r.t. Central Body vs. Time (Vernal Equinox)

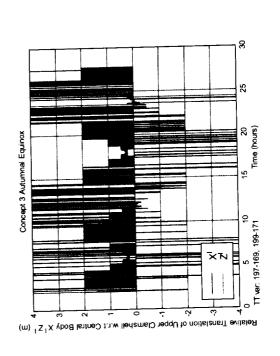


Figure B.2-17c: Relative Translation of Upper Clamshell w.r.t. Central Body vs. Time (Autumnal Equinox)

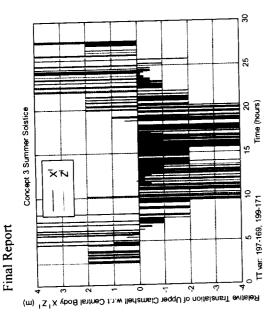


Figure B.2-17b: Relative Translation of Upper Clamshell w.r.t. Central Body vs. Time (Summer Solstice)

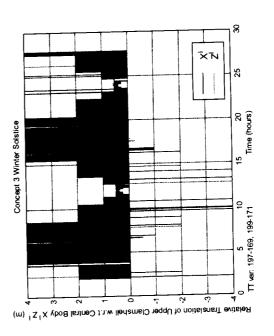


Figure B.2-17d: Relative Translation of Upper Clamshell w.r.t. Central Body vs. Time (Winter Solstice)

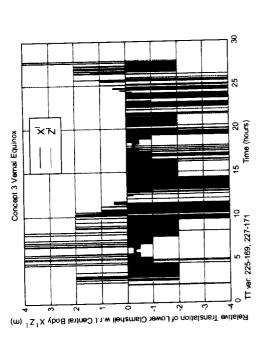


Figure B.2-18a: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Vernal Equinox)

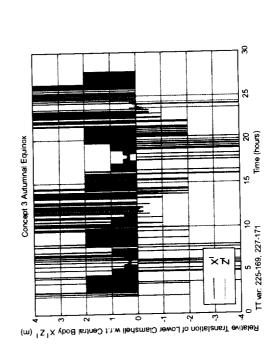


Figure B.2-18c: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Autumnal Equinox)

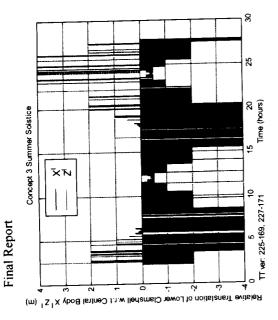


Figure B.2-18b: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Summer Solstice)

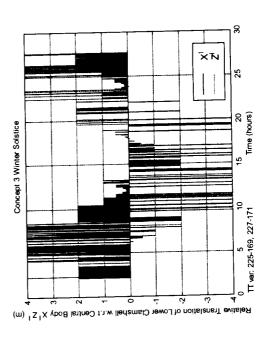


Figure B.2-18d: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Winter Solstice)

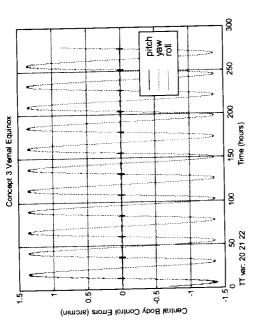


Figure B.2-19: Central Body Control Errors vs. Time (Vernal Equinox)

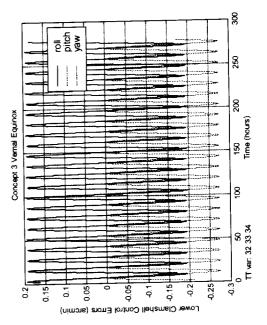


Figure B.2-21: Lower Clamshell Control Errors vs. Time (Vernal Equinox)

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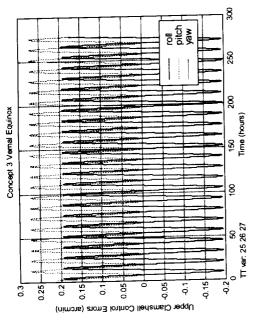


Figure B.2-20: Upper Clamshell Control Errors vs. Time (Vernal Equinox)

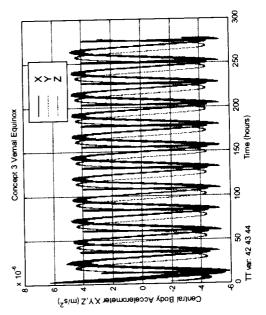


Figure B.2-22: Central Body Accelerometer vs. Time (Vernal Equinox)

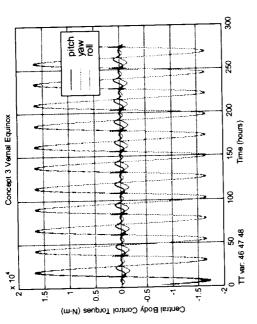


Figure B.2-23: Central Body Control Torques vs. Time (Vernal Equinox)

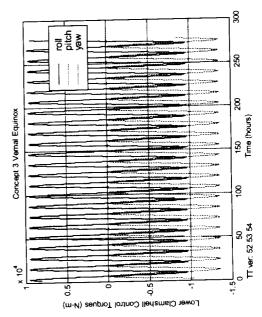


Figure B.2-25: Lower Clamshell Control Torques vs. Time (Vernal Equinox)

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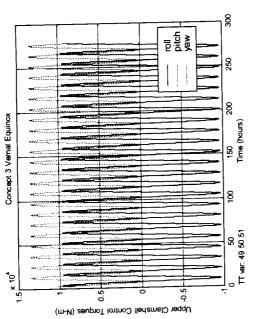


Figure B.2-24: Upper Clamshell Control Torques vs. Time (Vernal Equinox)

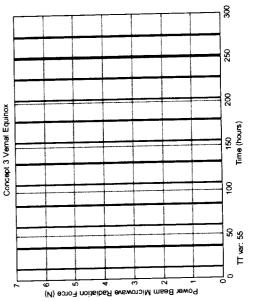


Figure B.2-26: Power Beam Microwave Radiation Force vs. Time (Vernal Equinox)

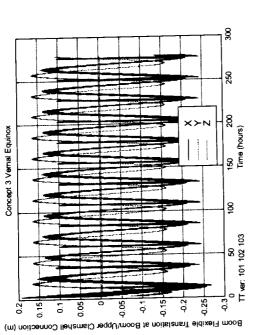


Figure B.2-27: Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Vernal Equinox)

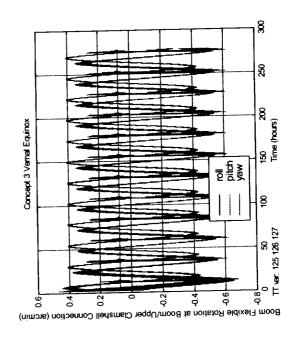


Figure B.2-29: Boom Flexible Rotation at Boom/Upper Clamshell Connection vs. Time (Vernal Equinox)

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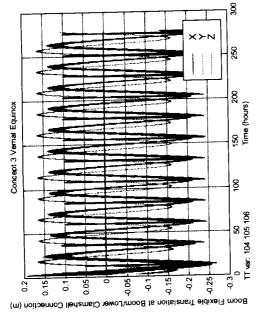


Figure B.2-28: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Vernal Equinox)

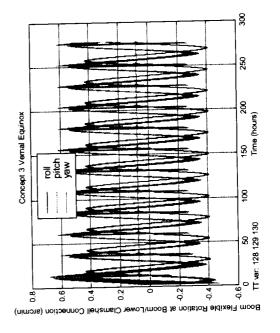


Figure B.2-30: Boom Flexible Rotation at Boom/Lower Clamshell Connection vs. Time (Vernal Equinox)

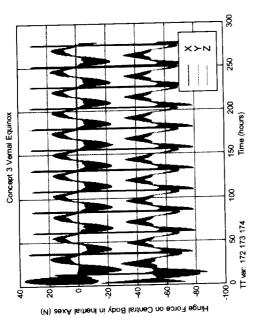


Figure B.2-31: Hinge Force on Central Body in Inertial Axes vs. Time (Vernal Equinox)

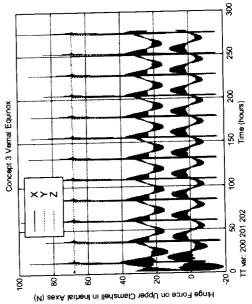


Figure B.2-33: Hinge Force on Upper Clamshell in Inertial Axes vs. Time (Vernal Equinox)

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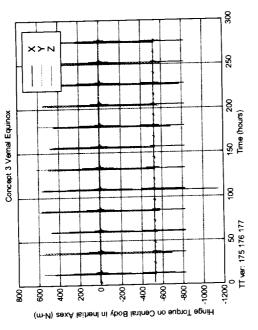


Figure B.2-32: Hinge Torque on Central Body in Inertial Axes vs. Time (Vernal Equinox)

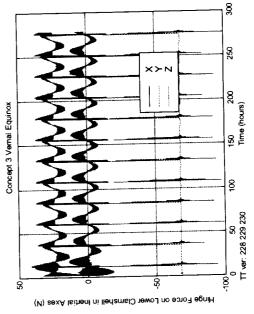


Figure B.2-34: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Vernal Equinox)

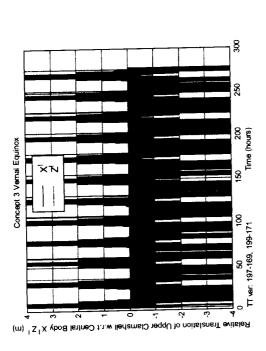


Figure B.2-35: Relative Translation of Upper Clamshell w.r.t. Central Body vs. Time (Vernal Equinox)

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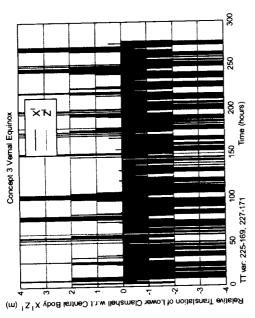


Figure B.2-36: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Vernal Equinox)

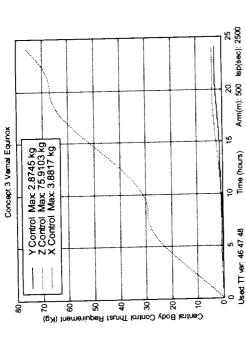


Figure B.2-37a: Central Body Control Thrust Requirement vs. Time for

(Vernal Equinox)

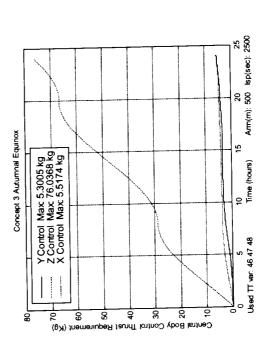


Figure B.2-37c: Central Body Control Thrust Requirement vs. Time for 1 Day (Autumnal Equinox)

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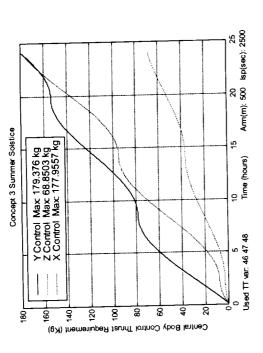


Figure B.2-37b: Central Body Control Thrust Requirement vs. Time for 1 Day

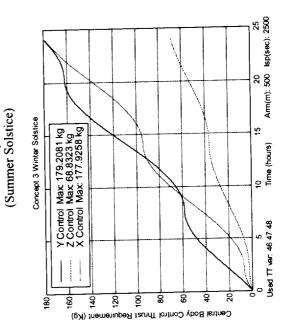


Figure B.2-37d: Central Body Control Thrust Requirement vs. Time for 1 Day
(Winter Solstice)

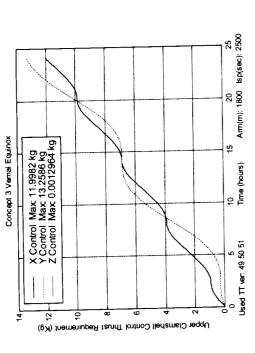


Figure B.2-38a: Upper Clamshell Control Thrust Requirement vs. Time for 1 Day (Vernal Equinox)

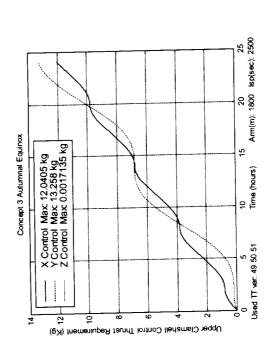


Figure B.2-38c: Upper Clamshell Control Thrust Requirement vs. Time for 1 Day (Autumnal Equinox)

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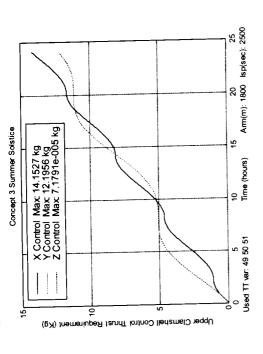


Figure B.2-38b: Upper Clamshell Control Thrust Requirement vs. Time for 1 Day

(Summer Solstice)

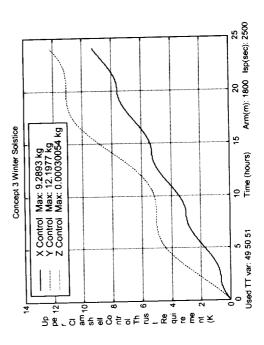


Figure B.2-38d: Upper Clamshell Control Thrust Requirement vs.

Time for 1 Day
(Winter Solstice)

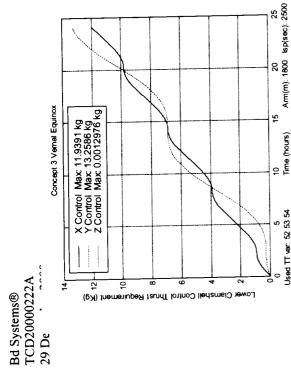


Figure B.2-39a: Lower Clamshell Control Thrust Requirement vs. Time (Vernal Equinox) for 1 Day

Used TT var. 52 53 54

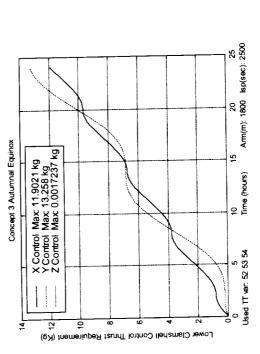


Figure B.2-39c: Lower Clamshell Control Thrust Requirement vs. Time (Autumnal Equinox)

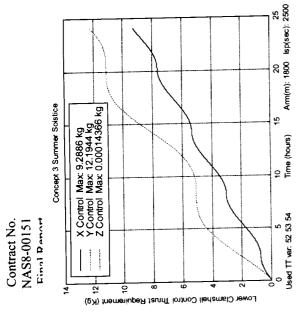


Figure B.2-39b: Lower Clamshell Control Thrust Requirement vs. Time for 1 Day

(Summer Solstice)

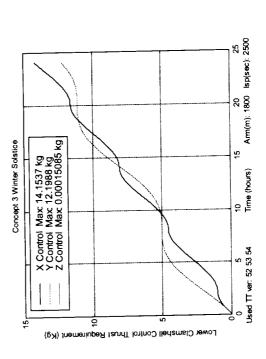


Figure B.2-39d: Lower Clamshell Control Thrust Requirement vs. Time for 1 Day

(Winter Solstice)

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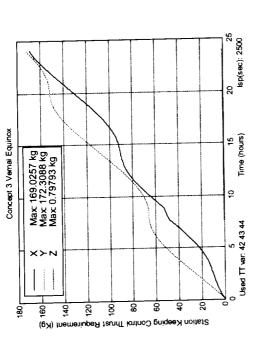


Figure B.2-40a: Estimated Station Keeping Control Thrust Requirement vs. Time for 1 Day (Vernal Equinox)

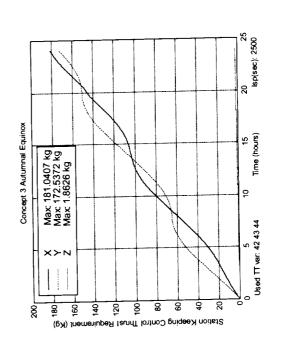


Figure B.2-40c: Estimated Station Keeping Control Thrust Requirement vs. Time for 1 Day (Autumnal Equinox)

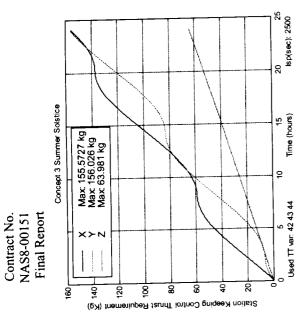


Figure B.2-40b: Estimated Station Keeping Clamshell Control Thrust Requirement vs. Time for 1 Day (Summer Solstice)

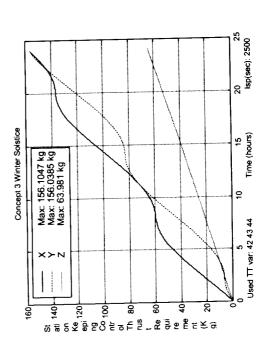


Figure B.2-39d: Estimated Station Keeping Control Thrust Requirement vs. Time for 1 Day (Winter Solstice)

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	rage	Z Control	72.407 255.417	8.5E-4 24.599	8.3E-4 24.550	, 72.409 304.566	
	Daily Average	Y Control	91.690	12.728	12.728	117.146	
	D	X Control	91.320	11.870	11.821	115.011	
-	ce	Z Control	68.832	3.01E-4	1.51E-4	68.832	
ncept 3)	Winter Solstice	Y Control	179.208	12.198	12.199	203.605	
Predicted Daily Thrust Requirements (Kg) (Concept 3)	 ₩	X Control	177.926	9.289	14.154	201.369	
uirements	inox	Z Control	76.037	12100.	.00172	76.040	
hrust Req	Autumnal Equinox	Y Control	5.301	13.258	13.258	31.817	
1 Daily Ti	Autu	X Control	5.517	12.041	11.902	29.460	
Predicted	ice	Z Control	68.850	7.2E-5	.00014	68.850	
Table B.2-1:	Summer Solstice	Y Control	179.376	12.196	12.194	203.768	
Tab	Sum	X Control	2.875 75.910 177.956	14.153	9.289	201.398	
	xoı	X Y Z Control Control	75.910	.00130	.00130	75.913	
	Vernal Equinox	Y Control		13.259	13.259	29.393	
	Ver	X Control	3.882	11.998	11.939	27.819	
		Description	Central Body	Control Upper Clamshell	Control Lower Clamshell	Control	

Notes:
1) Assumptions: Isp = 2500, Sec; Thrusters moment arm on Central Body = 500 m, Upper Clamshell = 1800 m, Lower Clamshell = 1800 m

	Total		362.320	
	ge	Z	32.656	
	Daily Average	Y	164.228	
	Da	×	165.436 164.228 32.656	
sept 3)	əc	7	63.981	
ed Daily Thrust Requirements (Kg) for Station Keeping (Concept 3)	Winter Solstice	>	.798 155.573 156.026 63.981 181.041 172.537 1.863 156.105 156.039 63.981	
ation Keep	Wii	×	156.105	
g) for Sta	you	Z	1.863	
ements (K	Autumnal Equinox	>	172.537	
ıst Require	Autur	×	181.041	
aily Thru	ice	Z	63.981	
redicted D	Summer Solstice	*	156.026	
Table B.2-2: Predicte	Sum	×	155.573	
Tabl	×	Z		
	Vernal Equinox	>	169.026 172.309	
	Ver	×	169.026	
		Description	Station Keeping Control	

Notes:

1) Assumptions: Isp = 2500. Sec; Total System Mass = 16921186.33 kg

		TABLE B.2-3:	: Predicted Daily a	Predicted Daily and Yearly Thrust Requirements (Kg) (Concept 3)	Requirements (Kg)	(Concept 3)		
	Daily Total					Yearly Total	Total	
Description	X Control	Y Control	Z Control	Total (1 Day)	X Control	Y Control	Z Control	Total (1 Year)
Central Body	91.320	91.690	72.407	255.417	33355.	33490.	26447.	93292.
Control Upper Clamshell	11.870	12.728	8.5E-4	24.599	4336.	4649.		8985.
Control Lower Clamshell	11.821	12.728	8.5E-4	24.550	4318.	4649.	-	8967.
Control	115.011	117.146	72.409	304.566	42009.	42788.	26447.	111244.
Notes:	= 2500. Sec; Thruste	rs mornent arm on Cer	itral Body = 500 m, Up	Notes: Notes: Notes: Notes: Notes: Thrusters moment arm on Central Body = 500 m, Upper Clamshell = 1800 m, Lower Clamshell = 1800 m	m, Lower Clamshell =	1800 m		

ents for Station Keeping (Kg) (Concept 3)	
TABLE B.2-4; Predicted Daily and Yearly Thrust Requirements for Station Keeping (Kg) (Concept 3)	

	Daily Total					Yearly Total	Total	
Description	×	>	Z	Total (1 Dav)	×	Å	Z	Total (1 Year)
Station Keeping Control	165.436	164.228	32.656	362.320	60425.	59984.	11928.	132337.

Notes: 1) Assumptions: 1sp = 2500. Sec; Total System Mass = 16921186.33 kg 2) 1 Year = 365.25 days

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B.3 – TREETOPS simulation results Comparison of Concept 1, 2A, 2B and 3 and Thrust Requirements for Concept 2A and 2B

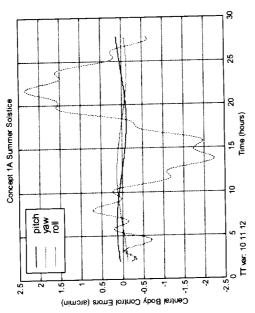


Figure B.3-1a: Central Body Control Errors vs. Time (Concept 1)

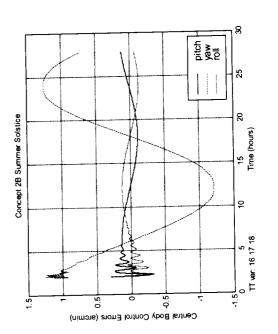


Figure B.3-1c: Central Body Control Errors vs. Time (Concept 2B)

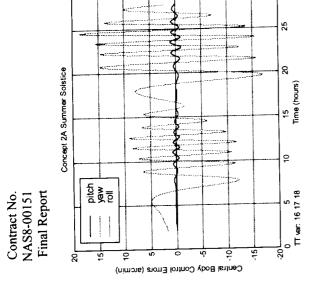


Figure B.3-1b: Central Body Control Errors vs. Time (Concept 2A)

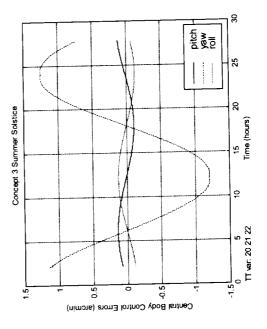


Figure B.3-1d: Central Body Control Errors vs. Time (Concept 3)



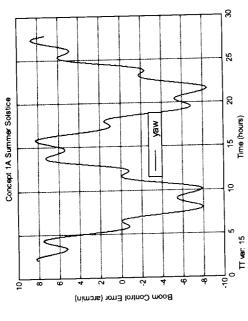


Figure B.3-2a: Boom Control Errors vs. Time (Concept 1)

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Figure B.3-2b: Boom Control Errors vs. Time (Concept 2A)

N/A

•

N/A

Figure B.3-2c: Boom Control Errors vs. Time (Concept 2B)

Figure B.3-2d: Boom Control Errors vs. Time (Concept 3)

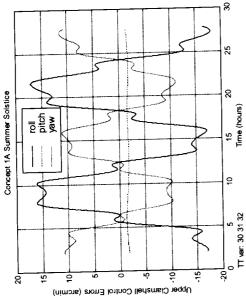


Figure B.3-3a: Upper Clamshell Control Епогs vs. Time (Concept 1)

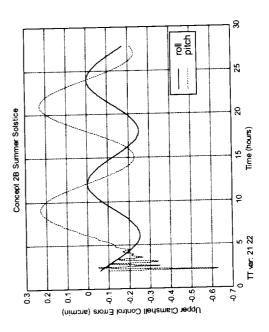


Figure B.3-3c: Upper Clamshell Control Errors vs. Time (Concept 2B)

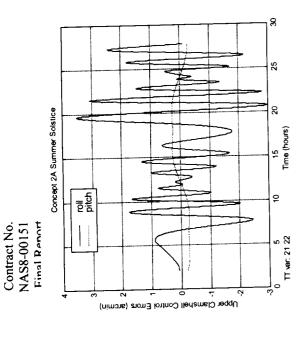


Figure B.3-3b: Upper Clamshell Control Errors vs. Time (Concept 2A)

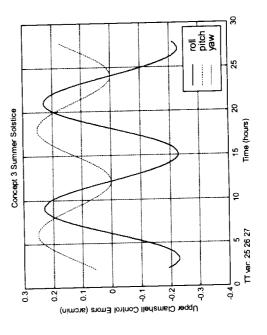


Figure B.3-3d: Upper Clamshell Control Errors vs. Time (Concept 3)



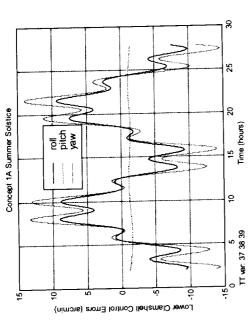


Figure B.3-4a: Lower Clamshell Control Errors vs. Time (Concept 1)

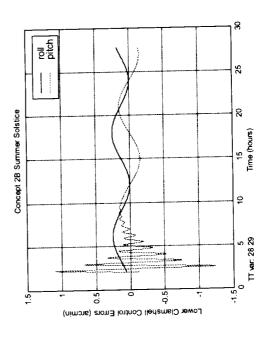


Figure B.3-4c: Lower Clamshell Control Errors vs. Time (Concept 2B)

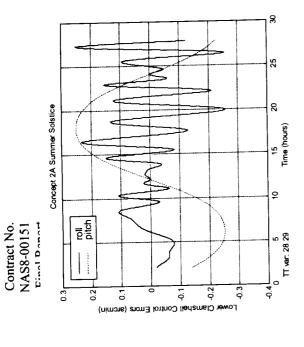


Figure B.3-4b: Lower Clamshell Control Errors vs. Time (Concept 2A)

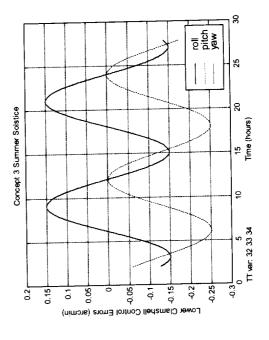


Figure B.3-4d: Lower Clamshell Control Errors vs. Time (Concept 3)

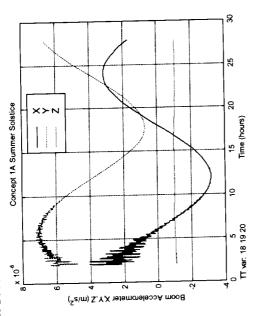


Figure B.3-5a: Central Body Accelerometer vs. Time (Concept 1)

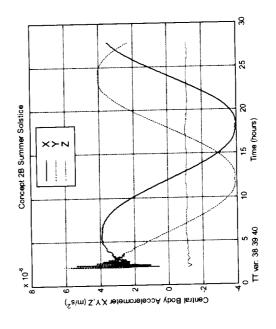


Figure B.3-5c: Central Body Accelerometer vs. Time (Concept 2B)

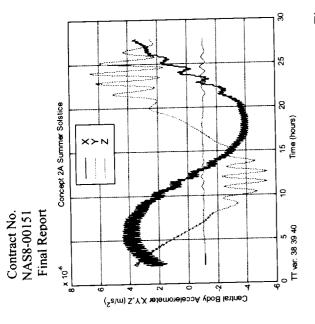


Figure B.3-5b: Central Body Accelerometer vs. Time (Concept 2A)

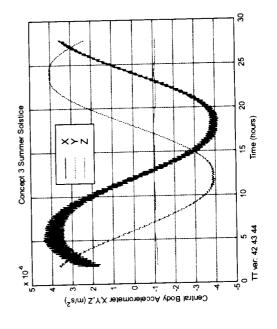


Figure B.3-5d: Central Body Accelerometer vs. Time (Concept 3)



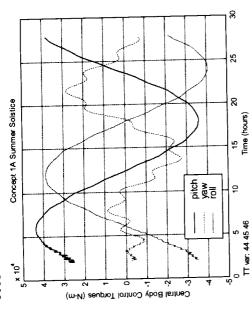


Figure B.3-6a: Central Body Control Torques vs. Time (Concept 1)

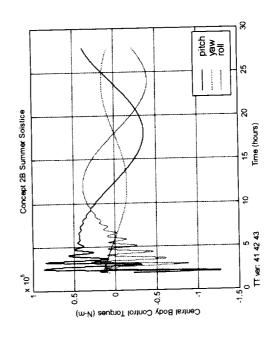


Figure B.3-6c: Central Body Control Torques vs. Time (Concept 2B)

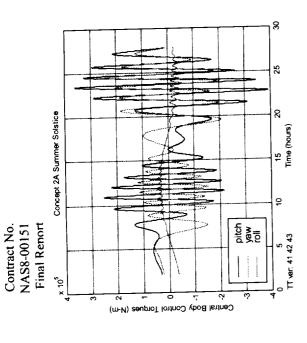


Figure B.3-6b: Central Body Control Torques vs. Time (Concept 2A)

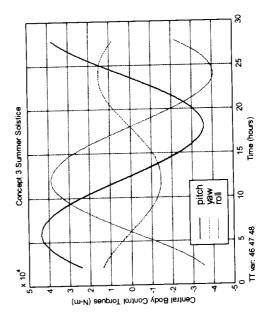
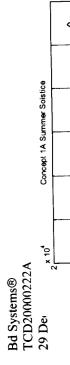


Figure B.3-6d: Central Body Control Torques vs. Time (Concept 3)



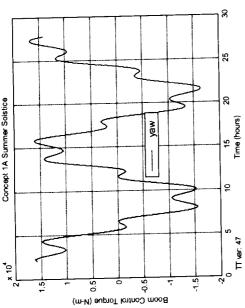


Figure B.3-7a: Boom Control Torques vs. Time (Concept 1)

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Figure B.3-7b: Boom Control Torques vs. Time (Concept 2A)

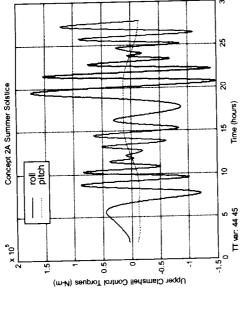
N/A

N/A

Figure B.3-7c: Boom Control Torques vs. Time (Concept 2B)

Figure B.3-7d: Boom Control Torques vs. Time (Concept 3)





Not Used for Control in this concept

Figure B.3-8b: Upper Clamshell Control Torques vs. Time (Concept 2A)

Figure B.3-8a: Upper Clamshell Control Torques vs. Time (Concept 1)

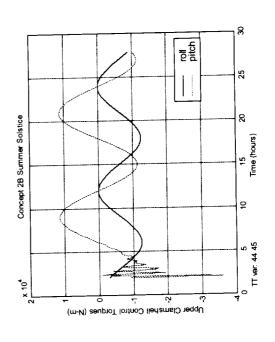


Figure B.3-8c: Upper Clamshell Control Torques vs. Time (Concept 2B)

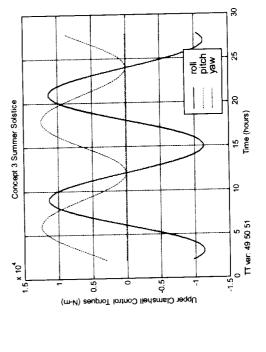


Figure B.3-8d: Upper Clamshell Control Torques vs. Time (Concept 3)

Not Used in Control

Figure B.3-9a: Lower Clamshell Control Torques vs. Time (Concept 1)

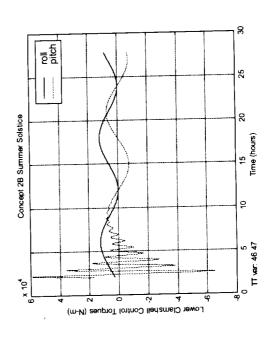


Figure B.3-9c: Lower Clamshell Control Torques vs. Time (Concept 2B)

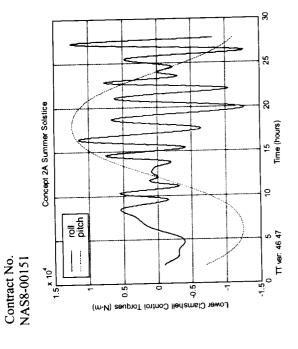


Figure B.3-9b: Lower Clamshell Control Torques vs. Time (Concept 2A)

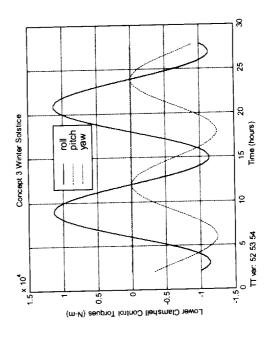


Figure B.3-9d: Lower Clamshell Control Torques vs. Time (Concept 3)

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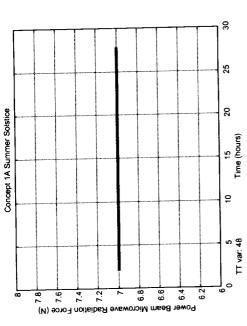


Figure B.3-10a: Power Beam Microwave Radiation Force vs. Time (Concept 1)

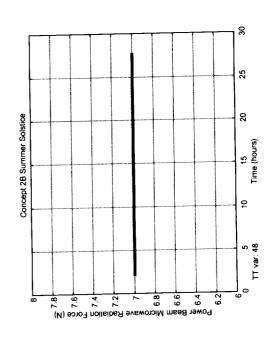


Figure B.3-10c: Power Beam Microwave Radiation Force vs. Time (Concept 2B)

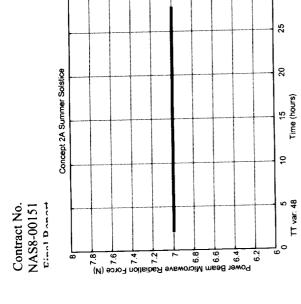


Figure B.3-10b: Power Beam Microwave Radiation Force vs. Time (Concept 2A)

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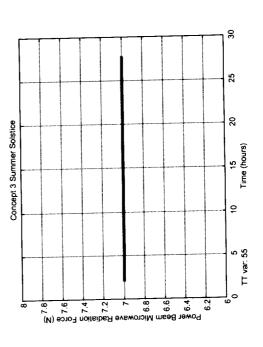


Figure B.3-10d: Power Beam Microwave Radiation Force vs. Time (Concept 3)





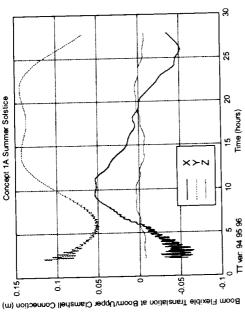


Figure B.3-11a: Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Concept 1)

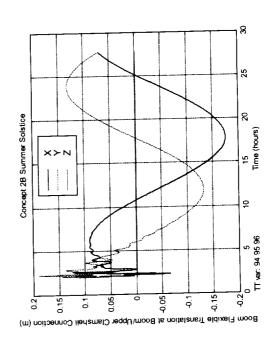


Figure B.3-11c: Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Concept 2B)

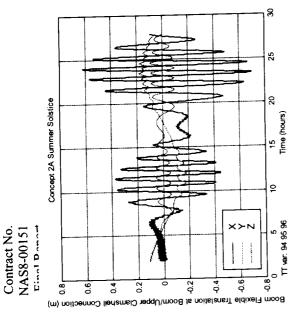


Figure B.3-11b: Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Concept 2A)

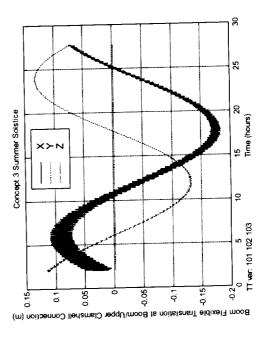


Figure B.3-11d: Boom Flexible Translation at Boom/Upper Clamshell Connection vs. Time (Concept 3)



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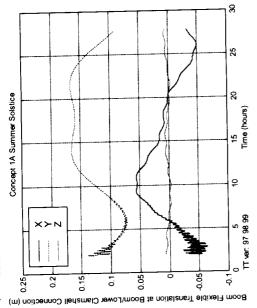


Figure B.3-12a: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Concept 1)

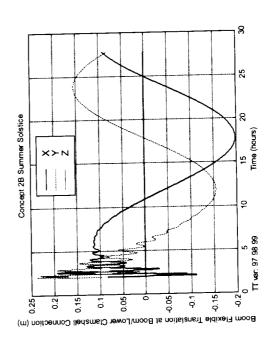


Figure B.3-12c: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Concept 2B)

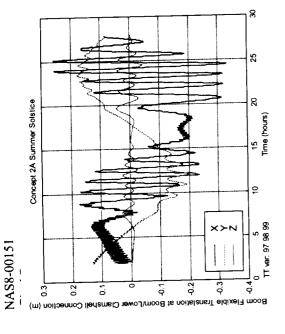


Figure B.3-12b: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Concept 2A)

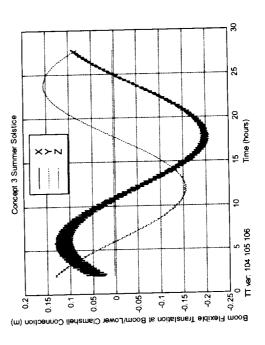
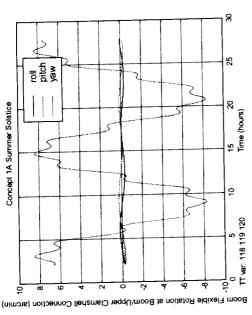
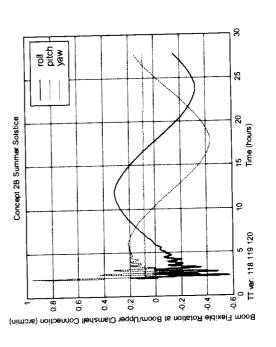


Figure B.3-12d: Boom Flexible Translation at Boom/Lower Clamshell Connection vs. Time (Concept 3)





Boom/Upper Clamshell Connection vs. Time Figure B.3-13a: Boom Flexible Rotation at (Concept 1)



Boom/Upper Clamshell Connection vs. Time Figure B.3-13c: Boom Flexible Rotation at (Concept 2B)

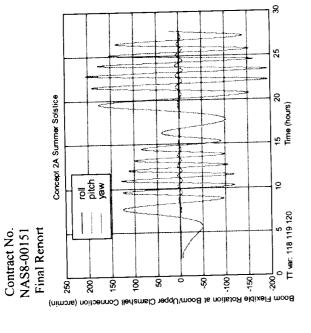
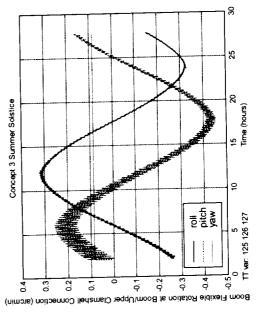


Figure B.3-13b: Boom Flexible Rotation at Boom/Upper Clamshell Connection vs. Time (Concept 2A)



Boom/Upper Clamshell Connection vs. Time Figure B.3-13d: Boom Flexible Rotation at (Concept 3)

Contract No.

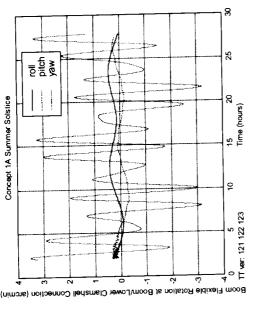


Figure B.3-14a: Boom Flexible Rotation at Boom/Lower Clamshell Connection vs. Time (Concept 1)

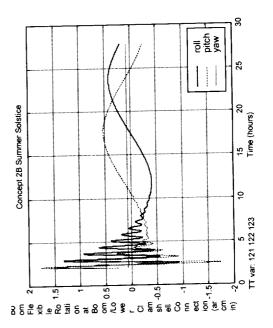


Figure B.3-14c: Boom Flexible Rotation at Boom/Lower Clamshell Connection vs. Time (Concept 2B)

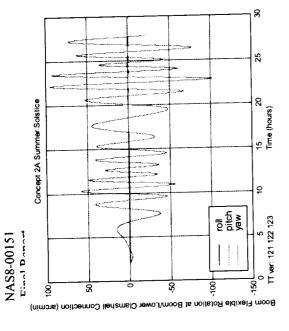


Figure B.3-14b: Boom Flexible Rotation at Boom/Lower Clamshell Connection vs. Time (Concept 2A)

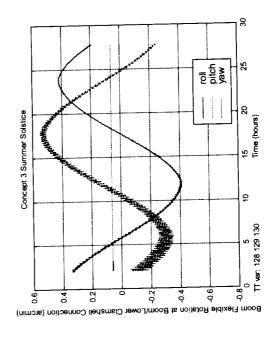


Figure B.3-14d: Boom Flexible Rotation at Boom/Lower Clamshell Connection vs. Time (Concept 3)

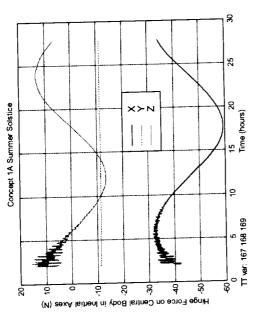


Figure B.3-15a: Hinge Force on Central Body in Inertial Axes vs. Time (Concept 1)

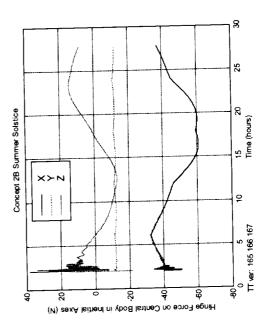


Figure B.3-15c: Hinge Force on Central Body in Inertial Axes vs. Time (Concept 2B)

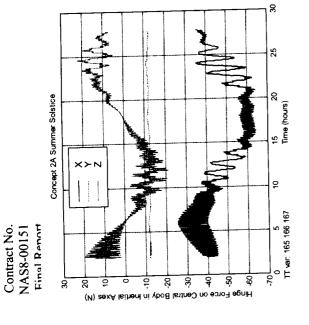


Figure B.3-15b: Hinge Force on Central Body in Inertial Axes vs. Time (Concept 2A)

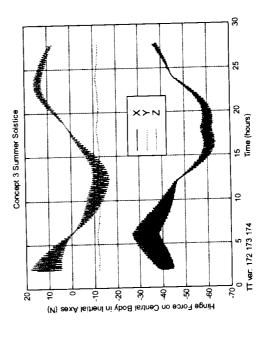


Figure B.3-15d: Hinge Force on Central Body in Inertial Axes vs. Time (Concept 3)

Contract No. NAS8-00151

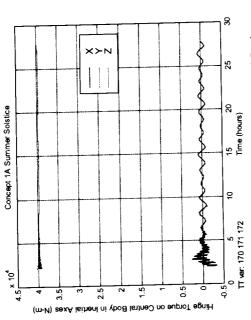


Figure B.3-16a: Hinge Torque on Central Body in Inertial Axes vs. Time (Concept 1)

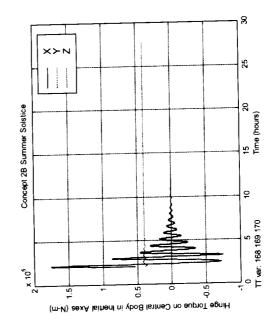


Figure B.3-16c: Hinge Torque on Central Body in Inertial Axes vs. Time (Concept 2B)

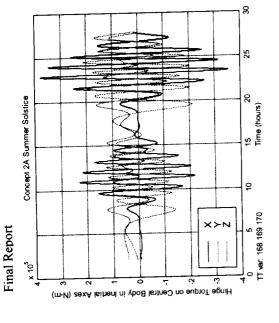


Figure B.3-16b: Hinge Torque on Central Body in Inertial Axes vs. Time (Concept 2A)

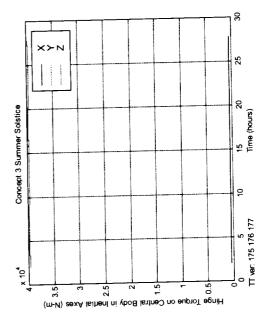


Figure B.3-16d: Hinge Torque on Central Body in Inertial Axes vs. Time (Concept 3)

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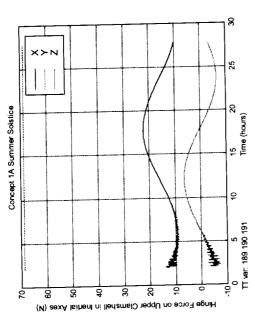


Figure B.3-17a: Hinge Force on Upper Clamshell in Inertial Axes vs. Time (Concept 1)

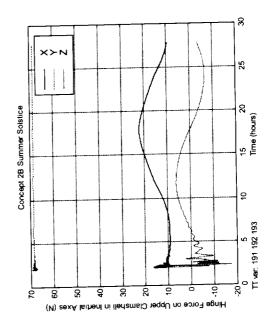


Figure B.3-17c: Hinge Force on Upper Clamshell in Inertial Axes vs. Time (Concept 2B)

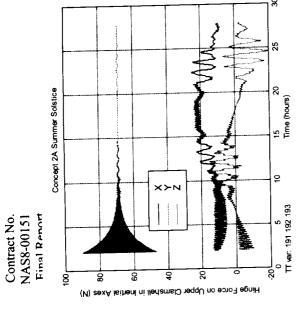


Figure B.3-17b: Hinge Force on Upper Clamshell in Inertial Axes vs. Time (Concept 2A)

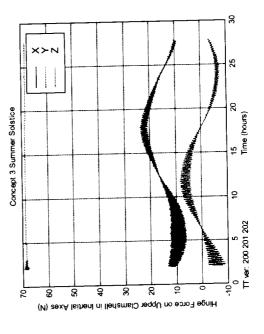


Figure B.3-17d: Hinge Force on Upper Clamshell in Inertial Axes vs. Time (Concept 3)

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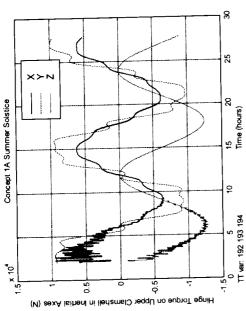


Figure B.3-18a: Hinge Torque on Upper Clamshell in Inertial Axes vs. Time (Concept 1)

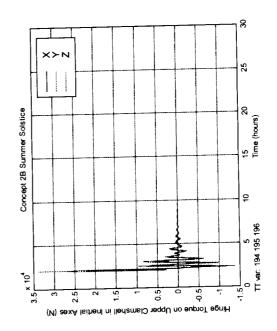


Figure B.3-18c: Hinge Torque on Upper Clamshell in Inertial Axes vs. Time (Concept 2B)

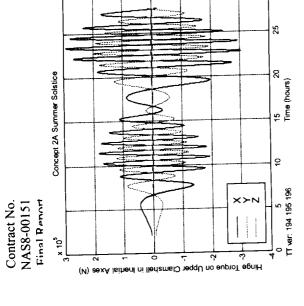


Figure B.3-18b: Hinge Torque on Upper Clamshell in Inertial Axes vs. Time (Concept 2A)

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Torque Curves are zero for Case 3

Figure B.3-18d: Hinge Torque on Upper Clamshell in Inertial Axes vs. Time (Concept 3)



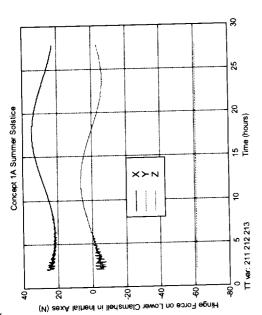


Figure B.3-19a: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Concept 1)

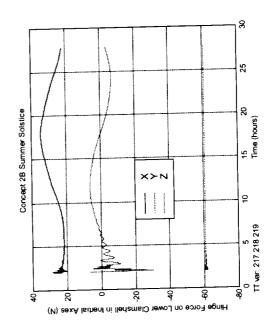


Figure B.3-19c: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Concept 2B)

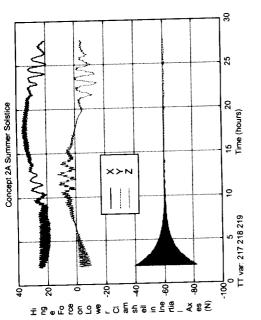


Figure B.3-19b: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Concept 2A)

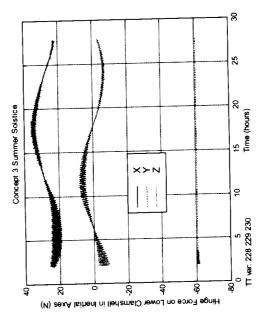


Figure B.3-19d: Hinge Force on Lower Clamshell in Inertial Axes vs. Time (Concept 3)



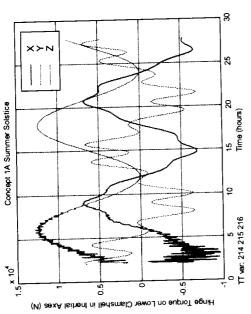


Figure B.3-20a: Hinge Torque on Lower Clamshell in Inertial Axes vs. Time (Concept 1)

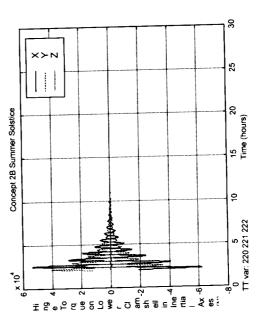


Figure B.3-20c: Hinge Torque on Lower Clamshell in Inertial Axes vs. Time (Concept 2B)

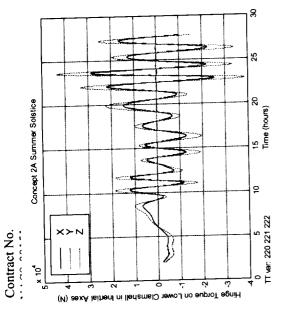
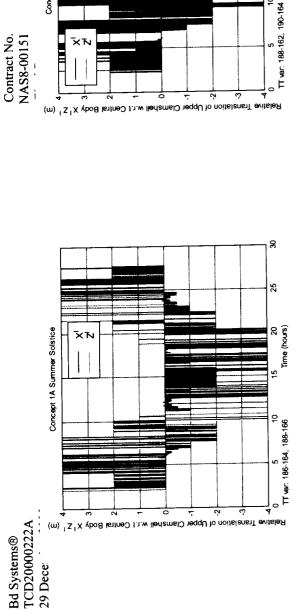


Figure B.3-20b: Hinge Torque on Lower Clamshell in Inertial Axes vs. Time (Concept 2A)

Torque Curves are zero for Case 3

Figure B.3-20d: Hinge Torque on Lower Clamshell in Inertial Axes vs. Time (Concept 3)



Concept 2A Summer Solstice

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Figure B.3-21a: Relative Translation of Upper Clamshell w.r.t. Central Body vs. Time (Concept 1)

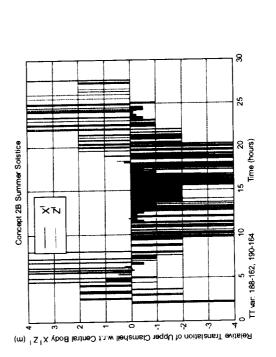
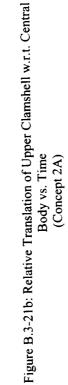


Figure B.3-21c: Relative Translation of Upper Clamshell w.r.t. Central Body vs. Time (Concept 2B)



5 20 Time (hours)

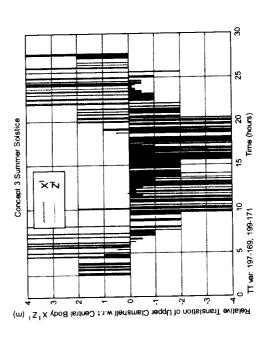


Figure B.3-21d: Relative Translation of Upper Clamshell w.r.t. Central Body vs. Time (Concept 3)

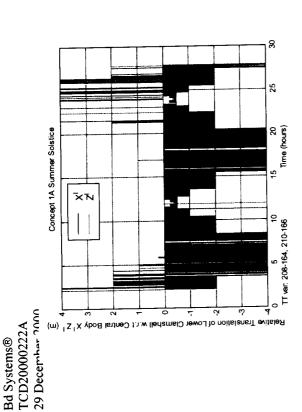


Figure B.3-22a: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Concept 1)

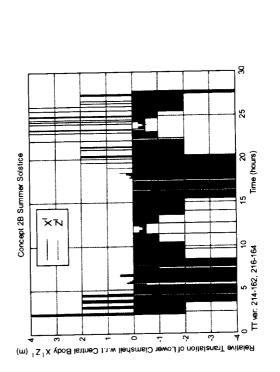


Figure B.3-22c: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Concept 2B)

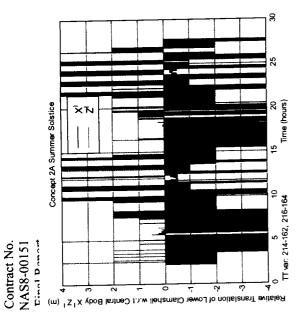


Figure B.3-22b: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Concept 2A)

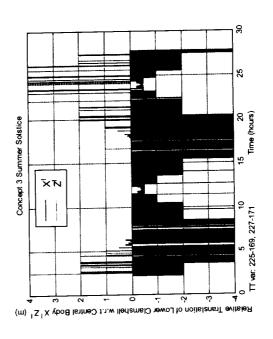


Figure B.3-22d: Relative Translation of Lower Clamshell w.r.t. Central Body vs. Time (Concept 3)

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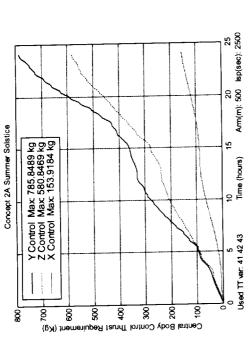


Figure B.3-23a: Central Body Control Thrust Requirement vs. Time for 1 Day (Concept 2A)

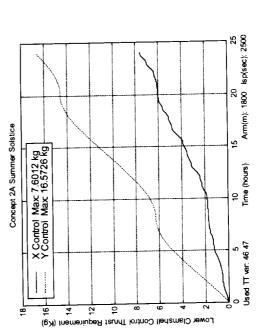


Figure B.3-23c: Lower Clamshell Control Thrust Requirement vs. Time for 1 Day (Concept 2A)

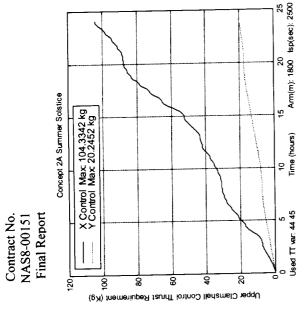


Figure B.3-23b: Upper Clamshell Control Thrust Requirement vs. Time for 1 Day (Concept 2A)

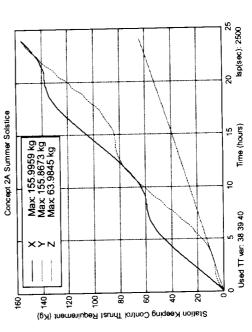


Figure B.3-23d: Station Keeping Control Thrust Requirement vs. Time for 1 Day
(Concept 2A)

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		Total	1091.554	108.63	26.968	1227.152
	že	Z Control	610.862	-		610.862
	Daily Average	Y Control	401.687	21.121	17.293	440.102
	Da	X Control	79.005	87.509	9.675	176.188
t 2A)	eo	Z Control	580.7	-	1	580.7
Table B.3-1: Predicted Daily Thrust Requirements (Kg) (Concept 2A)	Winter Solstice (Est.)		785.1	20.24	16.6	821.94
its (Kg)	Wi	X ol Control	153.9	68.5	11.6	234.
uiremen	inox	Z Contr	641.5	1	1	641.5
rust Req	Autumnal Equinox		23.2	22.0	18.0	63.2
aily Th	Autu	X Control	4.8	8.88	6.7	103.3
dicted D	ice	Z Control	580.847	:	;	580.847
3-1: Pre	Summer Solstice		785.849	20.245	16.573	822.667
Fable B.	Sun	X ol Control	153.918	104.334	7.601	265.853
•	inox	Y Z Control ol	640.4	1		640.4
	Vernal Equinox	Y Contr	12.6	22.0	18.0	52.6
	Ver	X Control	3.4	88.4	8.6	9.101
		Description	Central Body	Control Upper Clamshell	Control Lower Clamshell	Control

1) Assumptions: Isp = 2500. Sec; Thrusters moment arm on Central Body = 500 m, Upper Clamshell = 1800 m, Lower Clamshell = 1800 m; Total System Mass = 16921186.33 kg 2) Est. = Estimated using (Summer Solstice calc 2A/Summer Solstice calc 3A/Summer Solstice calc 3A/Summer Solstice calc 3D/X (Calc 3) for each case and component.

Table B.3-2: Predicted Daily Thrust Requirements (Kg) for Station Keeping (Concept 2A)	Winter Solstice Daily Average Total	y X X Z Y	155.9 64. 165.874 164.067 32.670 362.612
or Static	·	×	155.996 155.867 63.985 181.5 172.4 1.9 156.5 155.9
Kg) f	inox	2	6:1
ments (Autumnal Equinox (Est)	>	172.4
Require	Autu	×	181.5
Thrust	ice	Z	63.985
ed Daily	Summer Solstice (Calc.)	, A	155.867
Predicte	Sum	×	155.996
B.3-2:	×o	Z	.798
Table	Vernal Equinox (Est.)	, ,	
	Vei	×	5.691
		Description	Station Keeping 169.5 172.1 Control

1) Assumptions: Isp = 2500. Sec; Thrusters moment arm on Central Body = 500 m, Upper Clamshell = 1800 m, Lower Clamshell = 1800 m; Total System Mass = 16921186.33 kg 2) Est. = Estimated using (Summer Solstice calc 2A/Summer Solstice calc 3)x(calc 3) for each case and component. Notes:

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	TAB	TABLE B.3-3: Pred	icted Daily and	Yearly Thrust	Requirements	licted Daily and Yearly Thrust Requirements (Kg) (Concept 2A)	(A)	
	Daily Total					Yearly Total	Total	
Description	X Control	Y Control	Z Control	Total (1 Day)	X Control	Y Control	Z Control	Total (1 Year)
Central Body	79.005	401.687	610.862	1091.554	28857.	146716.	223117.	398690.
Control Upper Clamshell	87.509	21.121	1	108.630	31963.	7714.	1	39677.
Control Lower Clamshell	9.675	17.293		26.968	3534.	6316.	:	9850.
Control	176.188	440.102	610.862	1227.152	64353.	160747.	223117	448217.
Total								
Notes:			,		. 1000 - H-H - 1000	· · · · · · · · · · · · · · · · · · ·		

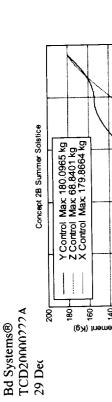
Notes:

1) Assumptions: Isp = 2500. Sec; Thrusters moment arm on Central Body = 500 m, Upper Clamshell = 1800 m, Lower Clamshell = 1800 m

2) I Year = 365.25 days

I	ABLE B.3-4:	TABLE B.3-4: Predicted Daily	and Yearly Ti	hrust Requirem	ents for Station	y and Yearly Thrust Requirements for Station Keeping (Kg) (Concept 2A)	(Concept 2A)	
	Daily Total					Yearly Total	Total	
Description	×	>	Z	Total (1 Dav)	×	*	2	Total (1 Year)
Station Keeping	165.874	164.067	32.670	362.611	60585.	59925.	11933.	132443.
Control								
Notes:								

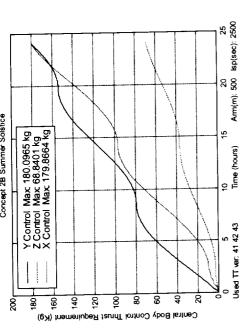
Notes: 1) Assumptions: 1sp = 2500. Sec; Total System Mass = 16921186.33 kg 2) 1 Year = 365.25 days



Concept 2B Summer Solstice

Contract No.

X Control Max: 12.1951 kg Y Control Max: 14.1591 kg



Upper Clamshell Control Thrust Requirement (Kg)

Figure B.3-24a: Central Body Control Thrust Requirement vs. Time for (Concept 2B)

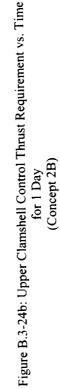
Concept 2B Summer Solstice

X Control Max 12.1939 kg Y Control Max 10.1604 kg

10

Lower Clamshell Control Thrust Requirement (Kg)

7



10 Time (hours)

Used TT var. 44 45

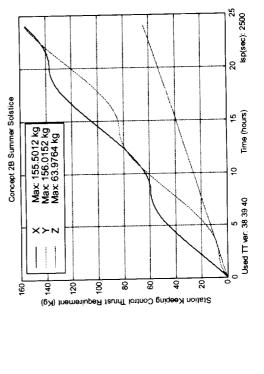


Figure B.3-24c: Lower Clamshell Control Thrust Requirement vs. Time (Concept 2B) for 1 Day

15

10 Time (hours)

5 Used TT var. 46 47

Figure B.3-24d: Station Keeping Control Thrust Requirement vs. Time (Concept 2B) for 1 Day

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		Total	256.752	25.014	26.114	307.880	
	ege	Z Control	72.385		-	72.385	
	Daily Average	Y Control	92.075	14.790	10.590	117.455	
	Ds	X Control	92.292	10.224	15.524	118.04	
t 2B)	e	Z Control	8.89	-	-	8.89	
Table B.3-5: Predicted Daily Thrust Requirements (Kg) (Concept 2B)	Winter Solstice (Est.)	Y Control	180.0	14.2	10.2	204.4	
nts (Kg)	Wi	X Control	179.8	8.0	9.81	206.4	
uiremer	inox	Z Control	76.0	-	1	76.0	
ust Req	Autumnal Equinox (Est.)	Y Control	5.3	15.4	11.0	31.7	
aily Thr	Autu	X Control	5.6	10.4	15.6	31.6	
icted D	ice	Z Control	68.840	1	,	68.840	
3-5: Pred	Summer Solstice (Calc.)	Y Control	180.100	14.159	10.160	204.255 204.419	
able B.3	Sun	X ol Control	179.866	12.195	12.194	204.255	
	vou	Z Contr	75.9	1	1	75.9	
	Vernal Equinox (Est.)		2.9	15.4	11.0	29.3	
	Ver	X Control	3.9	10.3	15.7	29.9	
		Description	Central Body	Control Upper Clamshell	Control Lower Clamshell	Total	

Notes:

1) Assumptions: Isp = 2500. Sec; Thrusters moment arm on Central Body = 500 m, Upper Clamshell = 1800 m, Lower Clamshell = 1800 m

2) Est. = Estimated using (Summer Solstice calc 2B/Summer Solstice calc 3)x(calc 3) for each case and component.

Table B.3-6: Predicted Daily Thrust Requirements (Kg) for Station Keeping (Concept 2B)

	Ver	/ernal Equinox	×c	Sum	Summer Solstice	ice	Autun	Autumnal Equinox (Est.)	xot	Wir	Winter Solstice (Est.)	e,	Ω	Daily Average	ge	Total
×		y Y	Z	×	X	Z	×	Å	Z	×	Å	Z	×	Å	Z	
	1					, 200	9	2 00.	670	0 731	156.0	72 076	165 350	156.0 63.076 165.350 164.203 32.206	32 653	362.206
168	6	168.9 172.3	.798	.798 155.501 156.01	156.015	63.976	115 63.976 181.0	0.001 0.001 0.7/1	500.1	130.0	0.001	0/2:50	000001	22-1-21	1	

1) Assumptions: lsp = 2500. Sec; Total System Mass = 16921186.33 kg
2) Est. = Estimated using (Summer Solstice cale 2B/Summer Solstice cale 3)x(cale 3) for each case and component.

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	TAB	LE B.3-7: Pred	TABLE B.3-7: Predicted Daily and Yearly Thrust Requirements (Kg) (Concept 2B)	l Yearly Thrust	Requirements	(Kg) (Concept	2B)	
	Daily Total					Yearly Total	Total	
Description	X Control	Y Control	Z Control	Total (1 Day)	X Control	Y Control	Z Control	Total (1 Year)
Central Body	92.292	92.075	72.385	256.752	33710.	33630.	26439.	93779.
Upper Clamshell	10.224	14.790	t o	25.014	3734.	5402.	1	9136.
Lower Clamshell	15.524	10.590	1	26.114	5670.	3868.	•	9538.
Total	118.040	117.455	72.385	307.880	43114.	42900.	26439.	112453.
Notes:							1 66 701 607	-

Notes:

1) Assumptions: Isp = 2500. Sec; Thrusters moment arm on Central Body = 500 m, Upper Clamshell = 1800 m, Lower Clamshell = 1800 m; Total System Mass = 16921186.33 kg

2) I Year = 365.25 days

132296. (1 Year) Total 11927. TABLE B.3-8: Predicted Daily and Yearly Thrust Requirements for Station Keeping (Kg) (Concept 2B) Z **Yearly Total** 59975. > 60394. × 362.206 (1 Day) Total 32.653 Z 164.203 > 165.350 × Daily Total Station Keeping Control Description

Notes:
1) Assumptions: Isp = 2500. Sec; Thrusters moment arm on Central Body = 500 m, Upper Clamshell = 1800 m, Lower Clamshell = 1800 m; Total System Mass = 16921186.33 kg
2) I Year = 365.25 days

B.4 -Thrust Requirements Comparison for Concept 1, Concept 2A, Concept 2B, Concept 3 and Stationkeeping

Table B.4-1: Predicted Thrust Requirements for Concept 1, Concept 2A, Concept 2B, Concept 3 and Stationkeeping

						Est.
Description			Daily Total			Annual Total
Description	VE	SS	AE	WS	ave	ave x 365.25
CI	97.27	439.988	101.44	439.74	269.610	98475.
C1 C2A	794.6	1669.367	808.0	1636.64	1227.152	448217.
	135.1	477.514	139.3	479.6	307.880	112453.
C2B	133.125	474.016	137.317	473.806	304.566	111243.
<u> </u>						
Stationkeeping C1	389.462	414.980	400.078	415.384	404.976	147917.
Stationkeeping C2A	342.398	375.848	355.800	376.400	362.612	132444.
Stationkeeping C2B	341.998	375.492	355.363	375.976	362.207	132296.
Stationkeeping C2B Stationkeeping C3	342.133	375.580	355.441	376.125	362.320	132337.

Notes:

- Control based on predictions in tables B.1-5 (for C1), B.3-1 (for C2A), B.3-5 (for C2B) and B.2-1 (for C3) Stationkeeping baseed on predictions in tables B.1-6 (for C1), B.3-2 (for C2A), B.3-6 (for C2B) and B.2-2 (C3).

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Appendix C

System Natural Frequencies

TREETOPS model system natural frequencies for the SSP ISC Configuration for concept 1, concept 2A, concept 2B and concept 3 are given herein. (Set the Z option in TREETOPS to obtain .MDK matrix.)

The steps to determine system natural frequencies are as follows:

- 1) set the Z option in TREETOPS and set to short run time
- 2) run TREETOPS
- 3) edit .MDK file and determine number of dof
- 4) edit run_read_m_d_k.m and update dof
- 5) run_read_m_d_k in MATLAB
- 6) run eig2 to determine frequencies and mode shapes.

```
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System Natural Frequencies (for Open Loop System) (Concept 1) (Hz):
(6 Rigid Body of System X, Y, Z, Roll, Pitch, Yaw)
(1 Rotations Free at Boom - Yaw )
                  0.0000000
                  0.0000000
         2
                  0.0000000
         3
                 0.0000000
         4
                  0.0000000
         5
                  0.0000000
         6
                  0.0000000
         7
                            torsion
                  0.0001656
         8
                  0.0009284
         9
                  0.0010580
         10
                            bending
                  0.0012894
         11
                  0.0014804
                            bending
         12
                  0.0016188
         13
                  0.0018034
         14
                  0.0046267
         15
                  0.0066675
         16
                  0.0207451
         17
                  0.0257265
         18
                  0.0289167
         19
                  0.0440772
         20
         21
                  0.0441270
                  0.0454749
         22
                  0.0456797
         23
                  0.0549901
         24
                  0.0831593
         25
                  0.3579221
         26
         27
                  0.3604716
                  0.5588000
         28
                  0.5588353
         29
                  0.5750994
         30
```

0.5751568

31

```
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System Natural Frequencies (for Open Loop System) (Concept 2A)
                                                                            (Hz):
(6 Rigid Body of System X, Y, Z, Roll, Pitch, Yaw)
(2 Rotations Free at UC - Roll, Pitch)
(2 Rotations Free at LC - Roll, Pitch)
                  0.0000000
         1
                  0.0000000
         2
                  0.0000000
         3
                  0.0000000
                  0.0000000
         5
                  0.0000000
          6
                  0.0000000
                 0.0000000
          8
                  0.0000000
                  0.0000000
        10
                            torsion
                  0.0002136
        11
                  0.0003722
                            torsion
        12
                            bending
                  0.0012078
        13
                            bending
                  0.0013254
        14
                  0.0045433
         15
                  0.0065539
         16
                  0.0228855
         17
         18
                  0.0288667
                  0.0426760
         19
         20
                  0.0428621
                  0.0439833
         21
         22
                  0.0443653
                  0.0530351
         23
                  0.0585215
         24
                  0.1828217
         25
                  0.3348567
         26
         27
                  0.3590667
                  0.3606646
         28
         29
                  0.4821389
                  0.4986634
         30
```

0.5682767

0.5904600

0.7300594

0.7300973

31

32

33

34

Contract No. Bd Systems® NAS8-00151 TCD20000222A Final Report 29 December 2000 System Natural Frequencies (for Open Loop System) (Concept 2B) (Hz): (6 Rigid Body of System X, Y, Z, Roll, Pitch, Yaw) (2 Rotations Free at UC - Yaw, Roll) (2 Rotations Free at LC - Yaw, Roll) 0.0000000 1 0.0000000 2 0.0000000 3 0.0000000 0.0000000 5 0.0000000 6 0.0000000 0.0000000 8 0.0000000 0.0000000 10 0.0009283 11 bending 0.0012884 12 bending 0.0013167 13 0.0016190 14 0.0046238 15 0.0065571 16 0.0210080 17 18 0.0219939 0.0269741 19 0.0297571 20 0.0428616 21 22 0.0440796 0.0443568 23 0.0454910 24 0.0869754 25 0.0914758 26 27 0.3583247 0.3605240 28 29 0.4821389 0.4986634 30 0.5588121 31

0.5751222

0.7300594

0.7300973

32

33 34

```
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System Natural Frequencies (for Open Loop System) (Concept 3)
                                                                                   (Hz):
 (6 Rigid Body of System X, Y, Z, Roll, Pitch, Yaw)
 (3 Rotations Free at UC - Roll, Pitch, Yaw)
 (3 Rotations Free at LC - Roll, Pitch, Yaw)
                    0.0000000
                    0.0000000
          3
                    0.0000000
                    0.0000000
          4
                    0.0000000
          6
                    0.0000000
                    0.0000000
                    0.0000000
          8
                    0.0000000
          9
                    0.0000000
         10
                    0.0000000
         11
                    0.0000000
         12
                                 bending
                    0.0012026
         13
                                 bending
                    0.0013171
         14
                    0.0045391
         15
                    0.0065538
         16
                    0.0210080
          17
          18
                    0.0219932
                    0.0269741
          19
          20
                    0.0297506
          21
                    0.0428128
                    0.0428639
          22
                    0.0441620
          23
                    0.0443726
          24
          25
                    0.0869754
                    0.0914758
          26
          27
                    0.3583247
                    0.3605240
          28
                    0.4821095
          29
                    0.4821525
          3.0
                    0.4986138
          31
          32
                    0.4986909
                    0.7300591
          33
          34
                    0.7300594
                    0.7300963
          35
                    0.7300973
 [Note: If The Upper and Lower Clamshell Rotations were fixed to the
        boom and all the mass moment of inertia of the clamshells were reacting against
        the boom, then the first natural frequency would be significantly lower:
            f7= .000165 Hz Torsion UC and LC in opposite directions
f8= .000342 Hz Torsion UC and LC in one direction, CB in the other
f9= .000930 Hz
f10= .00106 Hz
```

f11= .00129 Hz bending f12= .00148 Hz bending

(based on NASTRAN K123456 at UC and LC)]

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Appendix D

A NASTRAN Model Description of the Boom

A NASTRAN model description for the boom for the SSP ISC is given herein. A brief synopsis is provided. NASTRAN data files have been provided with the technical data package.

The NASTRAN boom only model is defined using the following files:

```
ssp5_boom_sf_ng_13loc_dy_aset.dat (Boom Normal Modes Run) include: ssp5_boom_top_sf.dat include: ssp5_boom_bot_sf.dat include: ssp5_connection_main_boom_top_13loc_a.dat include: ssp5_connection_main_boom_bot_13loc_a.dat
```

The model is in metric SI units: length=meters(m), mass=kg, force=Newtons, time=seconds. The NASTRAN Basic CS origin is at the intersection of the Boom vertical centerline and the Central Body. The NASTRAN Basic CS axes are: +x is in the direction of the power beam and perpendicular to z axis, +y is RHR, +z along boom centerline toward upper boom (North).

A representation of the SSP ISC Boom modeled in NASTRAN is given in Figures D.1 through D.4.

An excerpt of the top and bottom NASTRAN .dat files are provided for property and material definitions.

Boom only mass properties and boom normal mode frequencies are presented.

Static load deflections are given for the upper end of the upper boom that is fixed at the boom center (assume boom fixed at boom/central body interface) and for a boom that is loaded at the upper end.

Results for full-up verification analysis including a flexible boom with the central body and clamshell mass and inertia are also presented. Specifically, mass and normal mode frequencies are given for two cases:

Full-Up System Verification K123 (Clamshell Rotations Free - Roll, Pitch, Yaw) Full-Up System Verification K123456 (Clamshell Rotations Fixed to Boom)

Clamshell orientation for the full-up verification model is given in Figure D.5.

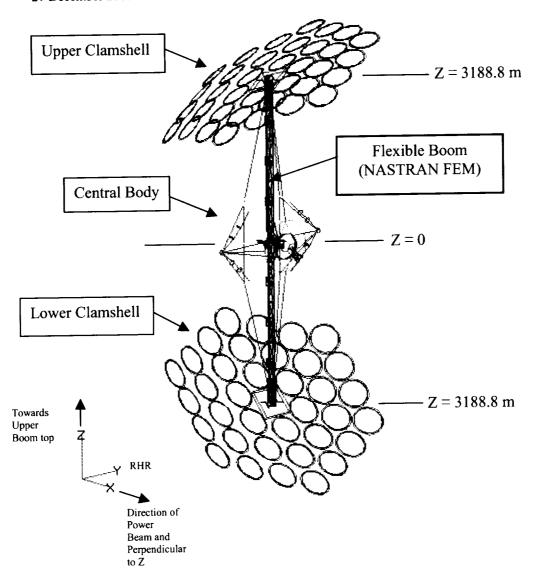


Figure D.1: SSP ISC Concept with NASTRAN Flexible Boom

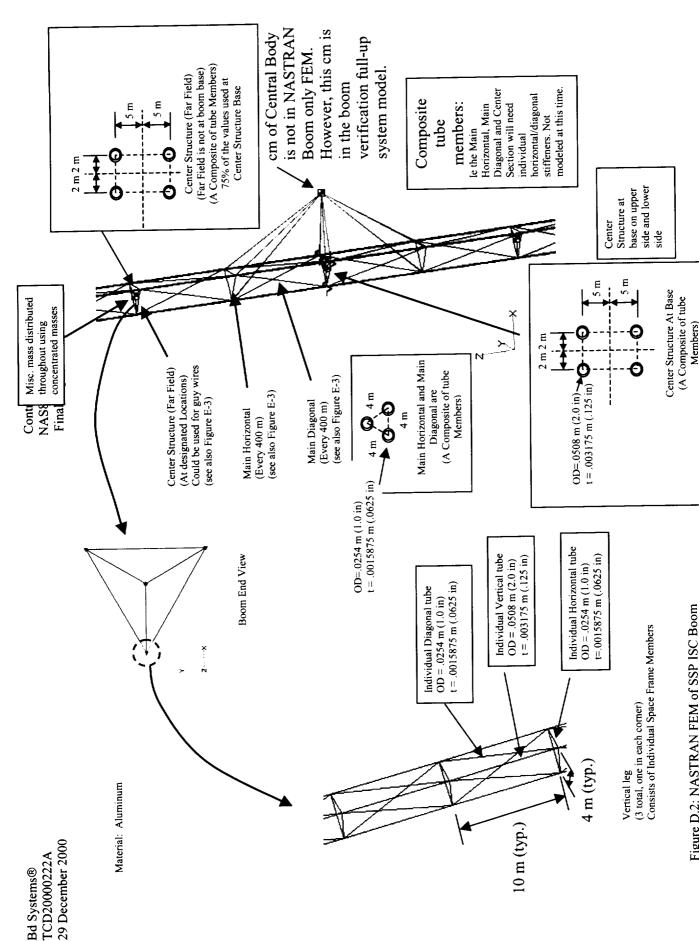


Figure D.2: NASTRAN FEM of SSP ISC Boom

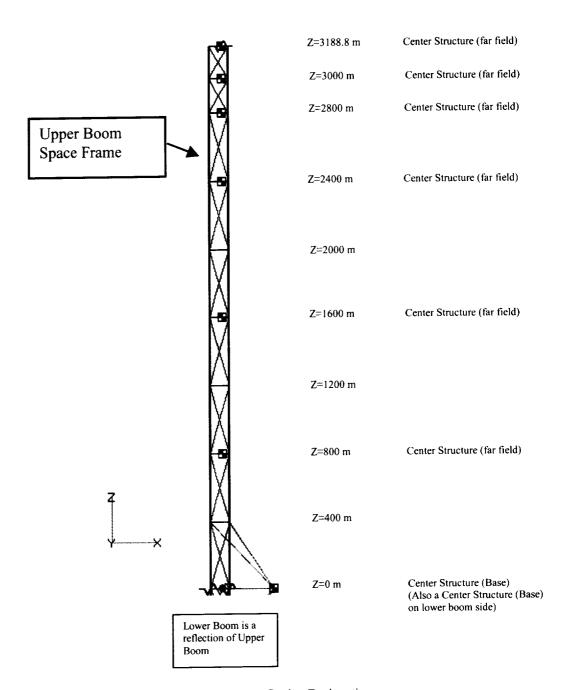


Figure D.3: Upper Boom Space Frame System: Station Designations

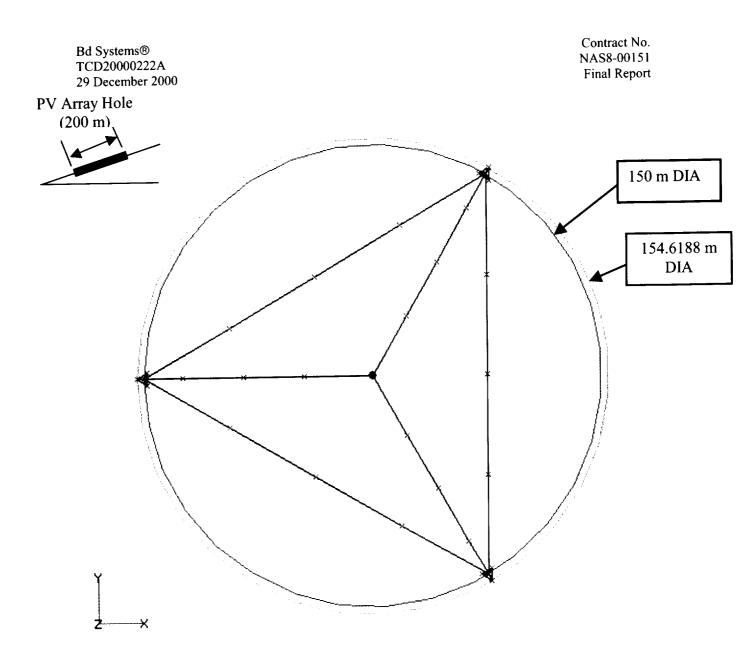


Figure D.4: Clearance Requirements of Boom:

```
$ ssp5_boom_top_sf.dat
$ Emmett McDonald
$ 11 Sept 2000
$ SSP Boom, Upper
$ Metric SI Units: Length=meters(m), mass=kg, Force=Newtons, time=seconds
$(+x - perpendicular to z axis in direction of beam, +y - RHR, +z along boom toward)
upper)
$ ASSUMPTION:
   Space Frame Concept - 123456 at cbars
   Main Vertical: EDGE - 3 composite frame groupings, each grouping consists of
                        of 3 individual vertical tubes and corresponding
                         individual horizontal and diagonal tubes
         1) Individual vertical tubes modeled as cbars
         2) Individual horizontal tubes modeled as cbars
S
         3) Individual diagonal tubes modeled as cbars
   Main: CENTER - Connects the main vertical edge frames to a center point
                  of boom at key stations along boom
         1) Composite Frame (assume square frame system) modeled as cbars
  Main: HORIZONTAL - Connects the 3 composite frame groupings at key stations
Ś
                     along the boom
         1) Composite Frame (assume triangular frame system) modeled as cbars
Ś
   Main: DIAGONAL - Connects the 3 composite frame groupings at key
                    stations along the boom
         1) Composite Frame (assume triangular frame system) modeled as cbars
   Interface Plates (Analytical): Massless Interface plates that transition
$
                                  loads of the individual tubes for a specific
$
                                  main vertical frame grouping into a center
$
                                  point for that frame grouping at key stations
Ś
                                  along the beam.
$
Š
$ ORGANIZATION:
$ ...PROPERTIES AND MATERIALS - Boom, Upper...
 ...CENTER BARS...
$ removed...INTERFACE PLATES - ANALYTICAL...
$ ...CBARS ALONG INTERFACE PLATES - ANALYTICAL...
$ ...MAIN HORZ...
$ ...MAIN DIAG...
$ ...MAIN VERTICAL - EDGE AND CENTER...
$ PROPERTIES AND MATERIALS - Boom, Upper
                                      $111111122222223333333344444444555555556666666677777778888888899999999900000000
$ BOOM - TOP
$ Metric Units A=m2, IXX, IYY, J = m4
 $ TUBE: OD = .0508 \text{ m} (2 in), t = .003175 \text{ m} (.125 in)
            101 100 4.75E-4 1.35E-7 1.35E-7 2.71E-7
$ TUBE: OD = .0254 \text{ m} (1 in), t = .0015875 \text{ m} (.125 in)
        102 100 1.19E-4 8.46E-9 8.46E-9 1.69E-8
$ TUBE: OD = .0254 \text{ m} (1 \text{ in}), t = .0015875 \text{ m} (.125 \text{ in})
                   100 1.19E-4 8.46E-9 8.46E-9 1.69E-8
            103
 $ CENTER STRUCTURE (AT BASE) - COMPOSITE TRUSS
$ Assume Square tube Pattern: 4 TUBES: .0508 m (2 in), t=.003175 m (.125 in)
                              +z/-z = +5m/-5m +/-y = +2m/-2m
                              Assume: A=4*indiv tube area
 $
                                      I=Ad^2
                   100 1.9E-3 4.75E-2 7.6E-3 5.51E-2
             111
 PBAR
 $ CENTER STRUCTURE ("NOT" AT BASE) - COMPOSITE TRUSS (USE 75% of these values)
```

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```

```
29 December 2000
$ Assume Square tube Pattern: 4 TUBES: .0508 m (2 in), t=.003175 m (.125 in)
                                    +z/-z = +5m/-5m +/-y = +2m/-2m
                                     Assume: A=4*indiv tube area
                                               I=Ad^2
                         100 1.43E-3 3.56E-2 5.7E-3 4.13E-2
               112
PBAR
$ MAIN HORZ - COMPOSITE TRUSS
PBAR 114 100 3.56E-4 9.5E-4 9.5E-4 1.9E-3
$ MAIN DIAG - COMPOSITE TRUSS
PBAR 115 100 3.56E-4 9.5E-4 9.5E-4 1.9E-3
$$$$$ $ Interface plates - Analytical $$$$$ PSHELL 180 180 .6
                                                  180
$$$$$$ $ CBARS along interface plates (Analytical) - zero mass and .6 m DIA solid
$$$$$ PBAR 181 180 .2827 6.36E-3 6.36E-3 1.27E-2
$ CBARS along interface plates (Analytical) - zero mass and .45 m DIA solid
          181 180 .1590 2.01E-3 2.01E-3 4.03E-3
PBAR
$ Metric Units: I=Kg-m2, E=N/m2, ro=kg/m3 $Aluminum E=7.10E10 N/m2 (10.3E6 lb/in2) ro=2.71E3 kg/m3 (.098 lb/in3 = 2.538E-4 lb-
s2/in)
                                          .30 2.71E3
MAT1
                100 7.10E10
$Aluminum - NO DENSITY
                                            .30 1.0E-1
              180 7.10E10
MAT1
Ś
$ MISC (1.37E3 at 6 locations) and Connection mass (.33E3 at 6 locations)
$111111122222223333333344444445555555566666666777777778888888899999999
           142001 108001 0 1.70E3
CONM2

    142001
    108001
    0
    1.70E3

    142002
    116001
    0
    1.70E3

    142003
    124001
    0
    1.70E3

    142004
    128001
    0
    1.70E3

    142005
    130001
    0
    1.70E3

    142006
    131901
    0
    1.70E3

CONM2
CONM2
CONM2
CONM2
CONM2
```

An excerpt of ssp5_boom_bottom_sf.dat

```
$ ssp5_boom_bot_sf.dat
$ Emmett McDonald
$ 11 Sept 2000
$ SSP Boom, Bottom
$ Metric SI Units: Length=meters(m), mass=kg, Force=Newtons, time=seconds
$ (+x - perpendicular to z axis in direction of beam, +y - RHR, +z along boom toward
upper)
$ ASSUMPTION:
   Space Frame Concept - 123456 at cbars
   Main Vertical: EDGE - 3 composite frame groupings, each grouping consists of
                         of 3 individual vertical tubes and corresponding
                         individual horizontal and diagonal tubes
         1) Individual vertical tubes modeled as cbars
         2) Individual horizontal tubes modeled as cbars
         3) Individual diagonal tubes modeled as cbars
   Main: CENTER - Connects the main vertical edge frames to a center point
                  of boom at key stations along boom
         1) Composite Frame (assume square frame system) modeled as cbars
   Main: HORIZONTAL - Connects the 3 composite frame groupings at key stations
                     along the boom
         1) Composite Frame (assume triangular frame system) modeled as cbars
   Main: DIAGONAL - Connects the 3 composite frame groupings at key
Ś
                            stations along the boom
         1) Composite Frame (assume triangular frame system) modeled as cbars
   Interface Plates (Analytical): Massless Interface plates that transition
                                  loads of the individual tubes for a specific
                                  main vertical frame grouping into a center
$
                                  point for that frame grouping at key stations
                                  along the beam.
Ś
$ ORGANIZATION:
$ ...PROPERTIES AND MATERIALS - Boom, Bottom...
$ ...CENTER BARS...
$ removed...INTERFACE PLATES - ANALYTICAL...
$ ...CBARS ALONG INTERFACE PLATES - ANALYTICAL...
$ ...MAIN HORZ...
  ...MAIN DIAG...
$ ...MAIN VERTICAL - EDGE AND CENTER...
... PROPERTIES AND MATERIALS - Boom, Bottom...
$-----
$11111112222222333333334444444455555555666666667777777888888889999999990000000
$ BOOM - BOTTOM
$ Metric Units A=m2, IXX, IYY, J = m4
 $ TUBE: OD = .0508 \text{ m} (2 in), t = .003175 \text{ m} (.125 in)
PBAR 201 200 4.75E-4 1.35E-7 1.35E-7 2.71E-7
 $ TUBE: OD = .0254 \text{ m} (1 \text{ in}), t = .0015875 \text{ m} (.125 \text{ in})
           202 200 1.19E-4 8.46E-9 8.46E-9 1.69E-8
 $ TUBE: OD = .0254 \text{ m} (1 in), t = .0015875 \text{ m} (.125 in)
                    200 1.19E-4 8.46E-9 8.46E-9 1.69E-8
            203
 PBAR
 $ CENTER STRUCTURE (AT BASE) - COMPOSITE TRUSS
$ Assume Square tube Pattern: 4 TUBES: .0508 m (2 in), t=.003175 m (.125 in)
                              +z/-z = +5m/-5m +/-y = +2m/-2m
                              Assume: A=4*indiv tube area
 Ś
                                      I=Ad^2
                    200 1.9E-3 4.75E-2 7.6E-3 5.51E-2
             211
 PBAR
 $ CENTER STRUCTURE ("NOT" AT BASE) - COMPOSITE TRUSS (USE 75% of these values)
 $ Assume Square tube Pattern: 4 TUBES: .0508 m (2 in), t=.003175 m (.125 in)
```

```
Contract No.
Bd Systems®
                                                                                     NAS8-00151
TCD20000222A
                                                                                      Final Report
29 December 2000
                                 +z/-z = +5m/-5m +/-y = +2m/-2m
                                 Assume: A=4*indiv tube area
$
                                           I=Ad^2
                      200 1.43E-3 3.56E-2 5.7E-3 4.13E-2
              212
PBAR
S MAIN HORZ - COMPOSITE TRUSS
PBAR 214 200 3.56E-4 9.5E-4 9.5E-4 1.9E-3
$ MAIN DIAG - COMPOSITE TRUSS
                   200 3.56E-4 9.5E-4 9.5E-4 1.9E-3
           215
PBAR
$$$$$ $ Interface plates - Analytical
                                                                280
                  280 280 .6
                                              280
$$$$$ PSHELL
$$$$$$ $ CBARS along interface plates (Analytical) - zero mass and .6 m DIA solid
$$$$$ PBAR 281 280 .2827 6.36E-3 6.36E-3 1.27E-2
$$$$$$ $ CBARS along interface plates (Analytical) - zero mass and .45 m DIA solid
            281 280 .1590 2.01E-3 2.01E-3 4.03E-3
Ś
S Metric Units: I=Kg-m2, E=N/m2, ro=kg/m3
$Aluminum E=7.10E10 N/m2 (10.3E6 lb/in2) ro=2.71E3 kg/m3 (.098 lb/in3 = 2.538E-4 lb-^{\circ}
s2/in)
                                       .30 2.71E3
              200 7.10E10
MAT1
$Aluminum - NO DENSITY
                                      .30 1.0E-1
MAT1
             280 7.10E10
Ś
\$ MISC (1.37E3 at 6 locations) and Connection mass (.33E3 at 6 locations)
$11111112222222333333334444444555555556666666677777778888888899999999
                            0 1.70E3
           242001 208001
242002 216001
CONM2
                                0 1.70E3
CONM2

    242003
    224001
    0
    1.70E3

    242004
    228001
    0
    1.70E3

    242005
    230001
    0
    1.70E3

    242006
    231901
    0
    1.70E3

CONM2
CONM2
CONM2
CONM2
```

\$

⊣ 0 0

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9 PAGE 12 0 (RESIDUAL) 07/21/99 SUPERELEMENT -1.439671E-01 0.000000E+00 4.491835E-09 -2.723725E-09 6.705735E+08 -3.544972E-05 IBM PC 2.192500E-10 -1.564216E-13 0.000000E+00 -2.472325E-13 2.192579E-10 0.000000E+00 Z-C.G. 0 E ď MATRIX PROCESSING FOR CSA/NASTRAN ĸ N E 6.984919E-10 -2.529123E-08 0.000000E+00 3.545100E-05 1.439671E-01 6.285218E+11 -4.041448E-03 6.285218E+11 - TRANSFORMATION MATRIX FOR SCALAR MASS PARTITION - RIGID BODY MASS MATRIX IN BASIC COORDINATE SYSTEM ы 0.000000E+00 * 0.000000E+00 * 1.000000E+00 * 4.041448E-03 -4.491870E-09 * 6.285218E+11 2.723725E-09 * 2.723725E-09 6.705735E+08 * Y-C.G. 6.705735E+08 * G 1.000000E+00 * 0.000000E+00 0.000000E+00 18, 19 0 H I(S) - INERTIAS RELATIVE TO C.G. ЕІСН E. McDonald, 23 Oct 2000 (BOOM ONLY) 1.439671E-01 -4.042393E-03 -2.019484E-28 -2.793968E-09 - TRANSFORMATION MATRIX - PRINCIPAL INERTIAS 0.000000E+00 -5.169879E-26 0.000000E+00 3.997411E-08 -3.197474E-31 -8.904096E-07 -8.904096E-07 I(Q) = QT*IBAR(S)*QOCT. X-C.G. 3 0.000000E+00 1.000000E+00 0.000000E+00 0.000000E+00 1.000000E+00 0.000000E+00 6.285218E+11 POINT REFERENCE POINT 1.616863E+05 3.545109E-05 1.616863E+05 1.616863E+05 1.616863E+05 * -4.491870E-09 (ŏ) I 1.000000E+00 GRID * 0.000000E+00 * 0.000000E+00 * 1.000000E+00 6.285218E+11 * 4.041448E-03 * 6.285218E+11 ø MASS 2.584939E-26 -8.488657E-13 1.616863E+05 0.000000E+00 -2.318702E-07 * 1.975422E-07 2.584939E-26 * -3.544975E-05 -1.439671E-01 0.000000E+00 Σ O MASS AXIS SYSTEM (S) Excerpt of ssp5_boom_sf_ng_13loc_dy_aset.f06, ĸ ſĿ, Ø DIRECTION õ H 0.000000E+00 1.616863E+05 * -1.139673E-12 Þ > N SSP5_BOOM_SF_NG_13LOC_DY_ASET.DAT UTP 0 NORMAL MODES ANALYSIS

0

0.000000E+00 0.000000E+00

-- 0

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SUPERELEMENT SOLUTION 07/21/99 PAGE 4.527360E+00 5.820129E+00 9.491925E+00 ..673878E+01 3.403545E+01 3.403549E+01 3.428328E+01 3.428331E+01 6.646430E-02 8.589462E-02 2.134917E-01 .282148E+01 .382777E+01 L.382779E+01 9.759543E-03 2.034302E-02 6.812558E-01 ..282150E+01 -5.122070E-09 1.088080E-08 6.154570E-08 9.759462E-03 6.646413E-02 2.134918E-01 2.951329E-01 4.354359E-01 6.812542E-01 -1.633329E-07 -1.309557E-07 -7.068505E-09 GENERALIZED STIFFNESS IBM PC 1.000000E+00 1.000000E+00 1.000000E+00 000000E+00 1.000000E+00 .000000E+00 .000000E+00 .000000E+00 .000000E+00 .000000E+00 .000000E+00 .000000E+00 .000000E+00 1.000000E+00 GENERALIZED OCT. 18, 19 0 CSA/NASTRAN 9.318828E-01 9.318833E-01 1.660163E-05 1.572291E-02 1.572298E-02 2.270010E-02 4.103116E-02 4.103121E-02 4.664478E-02 7.353780E-02 7.353780E-02 8.646273E-02 1.050225E-01 1.313635E-01 1.313636E-01 3.386434E-01 3.839604E-01 4.903399E-01 5.698877E-01 5.698880E-01 5.918289E-01 5.918293E-01 6.511514E-01 9.285085E-01 9.285091E-01 5.759467E-05 1.338086E-05 3.948380E-05 6.432163E-05 1.139050E-05 FREQUENCY CYCLIC EIGENVALUE 2.412494E+00 5.855193E+00 2.127759E+00 3.080897E+00 3.580710E+00 3.580712E+00 3.718571E+00 3.718573E+00 4.091305E+00 5.833991E+00 5.833994E+00 5.855196E+00 8.253822E-01 7.156864E-05 1.043111E-04 2.480840E-04 9.878999E-02 9.879040E-02 1.426290E-01 2.578064E-01 2.578067E-01 4.620516E-01 4.620517E-01 5.432613E-01 6.598757E-01 8.253813E-01 4.041447E-04 3.618780E-04 8.407440E-05 2.930779E-01 FREQUENCY RADIAN REAL 9.759543E-03 6.646413E-02 8.589462E-02 2.134917E-01 4.527360E+00 5.820129E+00 9.491925E+00 1.282148E+01 1.382777E+01 1.382779E+01 1.673878E+01 3.403545E+01 3.403549E+01 3.428328E+01 3.428331E+01 -7.068505E-09 -5.122070E-09 6.154570E-08 2.034302E-02 6.646430E-02 2.134918E-01 2.951329E-01 6.812542E-01 6.812558E-01 1.282150E+01 1.088080E-08 9.759462E-03 4.354359E-01 -1.633329E-07 -1.309557E-07 EIGENVALUE SSP5_BOOM_SF_NG_13LOC_DY_ASET.DAT NORMAL MODES ANALYSIS EXTRACTION ORDER 12 8 4 5 9 7 8 6 MODE N N

0

(An Upper Boom Base Fixed) ssp5_boom_sf_ng_13loc_st.f06 (Static Loads on Upper End of Upper Boom.
Excerpt)

NOV. 21, 19 0 CSA/NASTRAN IBM PC 07/21/99 PAGE 478 DATA RECOVERY FOR SUPERELEMENT 0 (RESIDUAL) SUBCASE 1001	встов	R1 R2 R3 6.106400E-06 1.098348E-04 -5.412926E-11 -2.906610E-07 1.052416E-05 1.819996E-11 NOV. 21, 19 0 CSA/NASTRAN IBM PC 07/21/99 PAGE 479 DATA RECOVERY FOR SUPERELEMENT 0 (RESIDUAL)	RCTOR	R1 R2 R3 -1.098349E-04 6.106408E-06 2.695994E-11 -1.052418E-05 -2.906613E-07 -2.143183E-11 NOV. 21, 19 0 CSA/NASTRAN IBM PC 07/21/99 PAGE 480 DATA RECOVERY FOR SUPERELEMENT 0 (RESIDUAL)	VECTOR	R1 R2 R3 2.960159E-14 7.269726E-13 -1.299740E-05 -4.560693E-15 -4.104938E-15 1.814090E-08 NOV. 21, 19 0 CSA/NASTRAN IBM PC 07/21/99 PAGE 481 DATA RECOVERY FOR SUPERELEMENT 0 (RESIDUAL) SUBCASE 1004	VECTOR	R1 R2 R3 9.498738E-05 -5.126904E-13 -1.491296E-11 2.000275E-06 -2.073411E-15 4.012494E-12 NOV. 21, 19 0 CSA/NASTRAN IBM PC 07/21/99 PAGE 482 DATA RECOVERY FOR SUPERELEMENT 0 (RESIDUAL) SUBCASE 1005	VECTOR
1 SSP5_BOOM_SF_NG_13LOC_ST.DAT STATIC ANALYSIS 0 LOAD FX = 20 N AT BOOM, UPPER END (TOP)	DISPLACEMENT V	POINT ID. TYPE T1 T2 T3 131901 G 2.517928E-01 1.002802E-08 2.008612E-10 231901 G -2.704772E-02 1.037041E-09 -1.256144E-11 - 1 SSP5_BOOM_SF_NG_13LoC_ST.DAT STATIC ANALYSIS 0 LOAD FY = 20 N AT BOOM, UPPER END (TOP)	DISPLACEMENT V	POINT ID. TYPE T1 T2 T3 131901 G 1.002802E-08 2.517929E-01 -1.257524E-10 - 231901 G 1.038834E-09 -2.704778E-02 9.964591E-12 - 1 SSP5_BOOM_SF_NG_13LoC_ST.DAT	DISPLACEMENT	POINT ID. TYPE T1 T2 T3 131901 G 2.008612E-10 -1.257524E-10 4.886293E-04 231901 G 1.295385E-11 -1.367107E-11 -6.568940E-06 1 SSP5_BOOM_SF_NG_131oC_ST.DAT STATIC ANALYSIS 0 LOAD MX = 10000 N-M AT BOOM, UPPER END (TOP)	DISPLACEMENT	POINT ID. TYPE T1 T2 T3 131901 G 3.053200E-03 -5.491742E-02 1.480079E-11 231901 G 1.453305E-04 5.262089E-03 -1.736071E-12 1 SSP5_BOOM_SF_NG_13LOC_ST.DAT STATIC ANALYSIS 0 LOAD MY = 10000 N-M AT BOOM, UPPER END (TOP)	DISPLACEMENT

R2 R3 9.498736E-05 1.255651E-11

T3 R1 3.634863E-10 -5.126902E-13

T2 3.053204E-03

5.491740E-02

TYPE G

POINT ID. 131901

0

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0 (RESIDUAL) 0 (RESIDUAL) 0 (RESIDUAL) O (RESIDUAL) 07/21/99 PAGE 07/21/99 PAGE 07/21/99 PAGE PAGE SUBCASE 2001 SUBCASE 2002 SUBCASE 2003 SUBCASE 1006 07/21/99 -1.819990E-11 2.525499E-11 1.255651E-11 3.563758E-03 -2.891001E-12 -1.540669E-04 -1.052416E-05 1.697622E-11 -1.098348E-04 -5.219564E-11 2.984677E-12 DATA RECOVERY FOR SUPERELEMENT .9 0 CSA/NASTRAN IBM PC 0
DATA RECOVERY FOR SUPERFLEMENT .9 0 CSA/NASTRAN IBM PC C DATA RECOVERY FOR SUPERELEMENT 19 0 CSA/NASTRAN IBM PC DATA RECOVERY FOR SUPERELEMENT IBM PC 2.000271E-06 2.906613E-07 -6.106408E-06 CSA/NASTRAN NOV. 21, 19 0 4.086835E-16 -1.491296E-11 -3.539443E-12 NOV. 21, 19 0 2.906610E-07 -6.106400E-06 NOV. 21, 19 0 1.052418E-05 1.098349E-04 NOV. 21, 19 0 ĸ VECTOR VECTOR VECTO -6.498701E-03 -1.367106E-11 1.246758E-10 1.295384E-11 -1.977961E-10 -2.130299E-12 Н DISPLACEMENT EMENT DISPLACEMEN LOAD FZ = 20 N AT BOOM, LOWER END (BOT) (BOOM AXIAL LOADING) DISPLAC 1.347998E-08 -9.099953E-09 1.038834E-09 9.916226E-09 1.453307E-04 -2.704778E-02 2.517929E-01 10000 N-M AT BOOM, UPPER END (TOP) LOAD FY = 20 N AT BOOM, LOWER END (BOT) LOAD FX = 20 N AT BOOM, LOWER END (BOT) 9.916227E-09 231901 G -5.262078E-03 1 SSP5_BOOM_SF_NG_13LOC_ST.DAT 231901 G 8.488112E-09 1 SSP5_BOOM_SF_NG_13LOC_ST.DAT 131901 G -2.704772E-02 231901 G 2.517928E-01 1 SSP5_BOOM_SF_NG_13LOC_ST.DAT 1.037040E-09 -2.706463E-08 1 SSP5_BOOM_SF_NG_13LOC_ST.DAT TYPE TYPE TYPE 00 **ი** ი STATIC ANALYSIS STATIC ANALYSIS STATIC ANALYSIS STATIC ANALYSIS LOAD MZ = POINT ID. POINT ID. 131901 231901 131901

0 VEC DISPLACEMENT

LOAD MX = 10000 N-M AT BOOM, LOWER END (BOT)

231901 G -1.977961E-10 1 SSP5_BOOM_SF_NG_13LOC_ST.DAT

STATIC ANALYSIS

0

0 (RESIDUAL)

SUBCASE 2004

07/21/99 PAGE

-4.260599E-15 -1.814087E-08 7.259546E-13 1.299740E-05

-3.472140E-15 2.969441E-14 NOV. 21, 19 0

T3 -6.568940E-06 4.886293E-04

> 9.964584E-12 1.246758E-10

-1.256144E-11

TYPE 0 0

POINT ID.

0

131901

VECTOR

DISPLACEMENT

.9 0 CSA/NASTRAN IBM PC CDATA RECOVERY FOR SUPERELEMENT

R1 R2 R3 2.000275E-06 4.087172E-16 -3.539443E-12 9.498738E-05 -5.096353E-13 1.477201E-11 NOV. 21, 19 0 CSA/NASTRAN IBM PC 07/21/99 PAGE 488 DATA RECOVERY FOR SUPERELEMENT 0 (RESIDUAL)	тоя	R1 R2 R3 -2.073404E-15 2.000271E-06 -2.891000E-12 -5.096353E-13 9.498736E-05 -1.282914E-11 NOV. 21, 19 0 CSA/NASTRAN IBM PC 07/21/99 PAGE 489 DATA RECOVERY FOR SUPERELEMENT 0 (RESIDUAL) SUBCASE 2006	ток	R1 R2 R3 4.012496E-12 2.984678E-12 -1.540669E-04 1.477201E-11 -1.282913E-11 3.563758E-03 NOV. 21, 19 0 CSA/NASTRAN IBM PC 07/21/99 PAGE 490 DATA RECOVERY FOR SUPERELEMENT 0 (RESIDUAL) SUBCASE 1001
T3 T3 C C C C C C C C C C C C C C C C C	EMENT VECTOR	T3 -2.052467E-12 -2.0734 3.629773E-10 -5.0963	EMENT VECTOR	T3 9.070449E-06 4.012 6.498701E-03 1.4777 NOV. 2
T2 -5.262089E-03 5.491742E-02 END (BOT)	DISPLACEMENT	T2 -1.453307E-04 -3.053204E-03 END (BOT)	DISPLACEMENT	T2 71592E-08 62750E-08
POINT ID. TYPE T1 131901 G -1.453305E-04 231901 G -3.053200E-03 _BOOM_SF_NG_13LOC_ST.DAT IC ANALYSIS LOAD MY = 10000 N-M AT BOOM, LOWER		POINT ID. TYPE T1 131901 G 5.262078E-03 231901 G -5.491740E-02 LBOOM_SF_NG_13LOC_ST.DAT IC ANALYSIS LOAD MZ = 10000 N-M AT BOOM, LOWER		POINT ID. TYPE T1 131901 G 9.099987E-09 -1.0 231901 G -2.609783E-08 1.2 BOOM_SF_NG_13LOC_ST.DAT IC ANALYSIS LOAD FX = 20 N AT BOOM, UPPER END (TOP)
POINT ID. TYPE 131901 G -1.4 231901 G -3.0 1 SSP5_BOOM_SF_NG_13LOC_ST.DAT STATIC ANALYSIS 0 LOAD MY = 10000 N-M AT		POINT ID. TYPE 131901 G 5.2 231901 G -5.4 SSP5_BOOM_SF_NG_13LOC_ST.DAT STATIC ANALYSIS LOAD MZ = 10000 N-M AT		POINT ID. TYPE 131901 G 9.0' 231901 G -2.6 SSP5_BOOM_SF_NG_13LOC_ST.DAT STATIC ANALYSIS LOAD FX = 20 N AT BOOM, '

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PAGE 10 (RESIDUAL) 07/21/99 PAGE NOV. 17, 19 0 CSA/NASTRAN IBM PC (MATRIX PROCESSING FOR SUPERELEMENT An Excerpt MASS X-C.G. Y-C.G. Z-C.G. 2-C.G. 692119E+07 -3.0552702-33 2.094990E-12 -1.494649E-15 692119E+07 2.233087E+02 0.000000E+00 -1.196786E-05 692119E+07 2.233087E+02 2.095066E-12 0.000000E+00 I(S) - INBRILAS RELATIVE TO C.G. GRID POINT WEIGHT GENERATOR REFERENCE POINT = 0 Full-Up System Verification K123 (Clamshell Rotations Free - Roll, Pitch, Yaw) S - TRANSFORMATION MATRIX FOR SCALAR MASS PARTITION MO - RIGID BODY MASS MATRIX IN BASIC COORDINATE SYSTEM 1.000000E+00 0.00000E+00 0.000000E+00 • 0.000000E+00 1.00000E+00 1.00000E+00 1.000000E+00 1.000000E+00 • 0.00000E+00 0.00000E+00 • 0.00000E+00 0.000000E+00 0.00000E+00 0.000000E+00 0.00000E+00 0.00000E+00 0.000000E+00 0.00000E+00 0.00 | 1.000000E+00 0.000000E+00 0.000000E+00 | 0.000000E+00 | 1.000000E+00 0.000000E+00 | 0.000000E+00 | 0.000000E+00 | 4.650430E+13 -3.875071E+03 4.522235E+04
 -3.875071E+03 4.919346E+13 1.139207E+05
 4.522235E+04 1.139207E+05 6.766123E+12 6.766123E+12 * Q - TRANSFORMATION MATRIX I(Q) - PRINCIPAL INERTIAS I(Q) = QT*IBAR(S)*Q4.919346E+13 MASS 1.692119E+07 1.692119E+07 1.692119E+07 * 4.650430E+13 SSP5_MAIN_SF_NG_CLAM_K123_DY_MOD2.DAT OUTPUT FROM MASS AXIS SYSTEM (S) DIRECTION NORMAL MODES ANALYSIS Verification Analysis: 0 ~ 0

0 1

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SUPERELEMENT SOLUTION 07/21/99 PAGE 5.882525E-16 5.882712E-16 2.397129E-11 2.314021E-10 5.709955E-05 2.941322E-16 5.881085E-16 5.882390E-16 6.849127E-05 1.695564E-03 6.357310E-02 -6.227084E-10 -3.684854E-10 -1.515650E-10 2.941186E-16 8.134064E-04 1.704217E-02 1.785241E-02 2.669046E-02 3.430796E-02 6.372374E-02 6.733700E-02 6.794554E-02 1.575687E-01 GENERALIZED STIFFNESS IBM PC .000000E+00 .000000E+00 1.000000E+00 1.000000E+00 1.000000E+00 1.000000E+00 .000000E+00 .000000E+00 .000000E+00 .000000E+00 .000000E+00 .000000E+00 .000000E+00 .000000E+00 ..000000E+00 ..000000E+00 ..000000E+00 ..000000E+00 1.000000E+00 1.000000E+00 1.000000E+00 ..000000E+00 ..000000E+00 L.000000E+00 1.000000E+00 GENERALIZED NOV. 17, 19 0 CSA/NASTRAN MASS 3.860086E-09 3.860192E-09 2.421050E-06 2.077699E-02 2.126515E-02 2.600148E-02 4.148591E-02 6.317644E-02 3.055134E-06 2.801847E-06 1.959384E-06 2.729489E-09 2.729552E-09 3.859658E-09 3.860131E-09 7.792303E-07 1.202642E-03 1.317158E-03 4.539143E-03 6.553559E-03 2.947933E-02 4.012886E-02 4.017637E-02 4.129971E-02 3.971572E-06 FREQUENCY IGENVALUES CYCLIC 1.715028E-08 4.896048E-06 7.556424E-03 2.495413E-05 919597E-05 1.760452E-05 1.231117E-05 1.714989E-08 2.425095E-08 2.425364E-08 2.425392E-08 2.425430E-08 1.521191E-05 8.275946E-03 2.852028E-02 4.117722E-02 1.305457E-01 1.336129E-01 1.852241E-01 1.633721E-01 521371E-01 2.524356E-01 2.594937E-01 .969493E-01 FREQUENCY ы RADIAN REAL SSP5_MAIN_SF_NG_CLAM_K123_DY_MOD2.DAT -1.515650E-10 2.941186E-16 2.941322E-16 5.881085E-16 5.882390E-16 5.882525E-16 5.882712E-16 2.314021E-10 5.709955E-05 6.849127E-05 1.695564E-03 1.785241E-02 3.430796E-02 6.357310E-02 -3.099192E-10 2.397129E-11 8.134064E-04 1.704217E-02 .669046E-02 .372374E-02 6.733700E-02 6.794554E-02 575687E-01 -6.227084E-10 -3.684854E-10 EIGENVALUE NORMAL MODES ANALYSIS EXTRACTION ORDER 4 6 7 8 8 10 10 MODE NO.

Verification Analysis:

An Excerpt Full-Up System Verification K123456 (Clamshell Rotations Fixed to Boom)

07/21/99 NOV. 17, 19 0 CSA/NASTRAN IBM PC (MATRIX PROCESSING FOR SUPERELEMENT) SSP5_MAIN_SF_NG_CLAM_K123_DY_MOD2.DAT NORMAL MODES ANALYSIS Н

PAGE 10 0 (RESIDUAL)

> OUTPUT FROM GRID POINT WEIGHT GENERATOR REFERENCE POINT = 0

> > 0

MO - RIGID BODY MASS WATRIX IN BASIC COORDINATE SYSTEM
1.692119E+07 -8.488657E-13 0.000000E+00 -5.169879E-26 -2.529123E-08 -3.544972E-05 -1.139673E-12 1.693119E+07 0.000000E+00 2.02310E+02 0.000000E+00 3.778649E+09 0.000000E+00 0.000000E+00 1.692119E-05 3.545100E-05 -3.778649E+09 0.000000E+00 0.023104E+02 3.545109E-05 4.656430E+13 -4.041448E-09 4.91835E-09 1.975422E-07 2.548938E-26 -3.778649E+09 -4.042393E-03 5.003726E+13 -1.139207E+05 -3.544975E-05 3.778649E+09 -2.019484E-28 -2.793968E-09 -1.139207E+05 7.609928E-12 -

S - TRANSFORMATION MATRIX FOR SCALAR MASS PARTITION

I(S) - INERTIAS RELATIVE TO C.G.

4.650430E+13 -3.875071E-03 4.52235E+04

-3.875071E-03 4.919346E+13 1.199207E+05

4.52235E+04 1.139207E+05 6.766123E+12

0

I(Q) - PRINCIPAL INERTIAS

Q - TRANSFORMATION MATRIX I(Q) = QT*IBAR(S)*Q

6.766123E+12

4.919346E+13

* 4.650430E+13

1.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 1.000000E+00 1.000000E+00 0.000000E+00 0.0000000E+00 0.000000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.000000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.

298

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SUPERELEMENT SOLUTION 07/21/99 PAGE 8.650443E-05 -3.403050E-10 1.076385E-06 4.630290E-06 4.456027E-05 6.563131E-05 2.071103E-02 3.299847E-02 6.701340E-02 6.716394E-02 7.099716E-02 7.160546E-02 7.839783E-02 9.186188E-02 -6.211539E-10 -1.573186E-10 -1.267169E-10 2.316232E-10 3.412004E-05 1.034806E-04 1.287677E-04 8.450979E-04 1.754916E-03 2.565429E-01 2.600097E-11 GENERALIZED STIFFNESS IBM PC 1.000000E+00 1,000000E+00 1.000000E+00 1.000000E+00 GENERALIZED NOV. 17, 19 0 CSA/NASTRAN MASS 1.996228E-06 1.791585E-06 8.115493E-07 2.422207E-06 1.651216E-04 3.424713E-04 9.296615E-04 1.062415E-03 1.289364E-03 1.480264E-03 1.619010E-03 1.806024E-03 4.626724E-03 6.667274E-03 2.290451E-02 2.891126E-02 4.120035E-02 4.124660E-02 4.240730E-02 4.258858E-02 4.456276E-02 4.823783E-02 8.061208E-02 3.966612E-06 2.935988E-06 FREQUENCY Ŋ CYCLIC GENVALUE н Ы 2.588695E-01 2.664529E-01 1.037490E-03 2.151811E-03 9.300776E-03 2.907057E-02 4.189172E-02 2.675920E-01 2.799961E-01 3.030873E-01 2.492296E-05 1.844736E-05 .254267E-05 1.125686E-05 5.099114E-06 1.521917E-05 5.841236E-03 6.675348E-03 8.101315E-03 1.017254E-02 1.134759E-02 1.439133E-01 1.816548E-01 2.591601E-01 5.065007E-01 FREQUENCY RADIAN REAL -3.403050E-10 -1.573186E-10 1.076385E-06 4.630290E-06 8.650443E-05 8.450979E-04 6.701340E-02 7.099716E-02 7.160546E-02 9.186188E-02 SSP5_MAIN_SF_NG_CLAM_K123_DY_MOD2.DAT -1.267169E-10 .316232E-10 3.412004E-05 4.456027E-05 6.563131E-05 1.034806E-04 1.287677E-04 1.754916E-03 2.071103E-02 3.299847E-02 6.716394E-02 7.839783E-02 2.565429E-01 -6.211539E-10 2.600097E-11 EIGENVALUE NORMAL MODES ANALYSIS EXTRACTION ORDER Š.

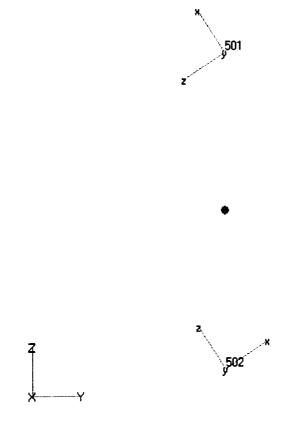


Figure D.5: Orientation of Upper and Lower Clamshells in NASTRAN Verification Runs:

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Orbiting space solar power space solar power (SSP) sar microwave radiation, and rexpected to be very flexible apply the expanded TREET the previous activity) to invsystem. SSP satellites are, orbiting environment where gravity model is required. selection, has been provide	tellites are require econversion to ele e presenting uniq TOPS multi-body vestigate the cont as noted, large of e the non-uniforn The current active d by NASA with	lectrical power at earth stati ue problems associated with dynamics analysis computer of problems associated with robital systems having many in gravitational forces may be returned by a stational forces of the reduced scope from that o	ons or at remote lo h their dynamics at er simulation prog th the integrated sy bodies (perhaps ho be the major load p 23 SERT proposal	cations in space. These land control. The purpose of ram (with expanded capab mmetrical concentrator (IS undreds) with flexible array roducers on the structure s (submitted 5-99). Funding	rge structures are f this project is to ilities developed in GC) conceptual SSP ys operating in an o that a high fidelity		
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